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The Use of Black Poplar (*Populus balsamifera L.*) Crowns for Gold Vegetation Geochemical Surveys in Burned Boreal Forest-Preliminary Results

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ABSTRACT

The crowns of two year old black poplar (*Populus balsamifera L.*) trees, growing in a previously burned boreal forest near Bissett, were collected adjacent to a high grade (229.4 g/tonne Au) quartz vein type gold occurrence and from an area with no known mineralization. Samples were analyzed by neutron activation for 35 elements in ashed plant material. Black poplar crowns collected adjacent to the mineralized zone are enriched in Ba, Cs, Co, Fe, Na, Zn, La and As relative to background samples. Geochemical contrast among the samples is greatest for Ba, Co and Cs. There is no apparent relationship between the concentration of an element of interest in ashed plant tissue and the same element in rock samples from the mineralized zone. Although only 14 vegetation samples were analyzed for this survey, black poplar crowns offer promise as a vegetation geochemical sampling medium for use in burned boreal forest.

INTRODUCTION

The applicability of vegetation geochemical surveys to gold and base metal exploration in boreal forests damaged by forest fires has undergone little investigation. Although meaningful data have been derived from routine vegetation analysis during exploration programs worldwide, the apparent lack of sampling media and the unknown effects of forest fire on element fluctuation in vegetation have retarded examinations in the "burned" environment.

This brief study was conducted in the Bissett area of southeastern Manitoba (Fig. 1) to determine if meaningful variations in trace and major element concentrations exist in vegetation growing with proximity to a high grade Au-Cu-Fe quartz vein occurrence. This study also provides baseline geochemical data useful in larger surveys in the Bissett area based upon the analysis of black poplar crowns.

The boreal forest surrounding the SL occurrence was burned in 1987. Although various scattered vegetation species have begun to re-establish themselves in the burn area the predominant species is black poplar (*Populus balsamifera L*). These two-year-old vigorous black poplars are growing approximately 20 cm apart and have attained heights of 1.5-1.8 m and an average diameter of 0.5 cm since deforestation by fire. The mineralized zone is exposed in outcrop and is surrounded by abundant black poplar growing between burned black spruce (*Picea mariana*) and pine (*Pinus banksiana*; Fig. 2a, b). There is very little indication of disturbed overburden. Relief is generally low in the area with minor ponded water.

GEOLOGY OF THE STUDY AREA

The study area is within the Rice Lake greenstone belt (Fig. 1) that forms part of the Uchi subprovince of the Archean Superior Province of the Canadian Shield. Approximately 46 655 kg of gold have been produced from mineral deposits in this belt. The SL occurrence, about which this orientation vegetation geochemical survey was undertaken, occurs within Bidou Lake Subgroup felsic fragmental volcanic rocks that are stratigraphically overlain by sedimentary rocks of the Edmunds Lake Formation (Fig. 3). The occurrence comprises a 120 m long white quartz vein containing native gold, and 2-3% disseminated chalcopyrite and pyrite. The vein pinches and swells over its observed strike length and attains thicknesses of 0.4 m. The host rocks are silicified felsic fragmental rocks that contain 2% disseminated chalcopyrite and pyrrhotite and have been intruded by fine grained mafic dykes. The vein occurs in a 1 m wide zone marked by strongly foliated rusty-weathered to rotten host rocks. Local malachite staining is present. Grab samples of the mineralized quartz vein contain a range in gold values of 62.7-229.4 g/tonne.

Overburden in the general area of the occurrence is characterized by a 12-15 cm thick upper layer of humus and forest litter underlain by 3 m of fine grey dense lacustrine clay (Fig. 2c). Depth to bedrock averages between 3 and 4 m.

SAMPLE COLLECTION, PREPARATION AND ANALYSIS

A suite of 14 poplar crown samples was collected from the area of the occurrence. Five "proximal" samples were collected from the immediate vicinity of the gold-bearing quartz vein (P-88-1 to P-88-5) and another nine samples were collected 150 m from the mineralization to serve as "background" samples (Fig. 4). Each sample consists of the upper 40 cm (i.e. the crown) of 10 black poplar trees within a 2 m sampling "box". The leaves were discarded and the stem and twigs were bulked for each sample site, dried, cut into 1 cm pieces and macerated. A representative split of macerated sample was ashed at 450°C and analyzed by neutron activation (NAA) for a suite of 35 elements by Activation Laboratories Ltd. (Brantford). Cu in the previously irradiated ash was analyzed by atomic absorption spectrophotometry after a perchloric acid digestion. The Cu analysis was undertaken by Barringer Laboratories Ltd. (Alberta) Ltd. Two rock samples were collected from the occurrence . These represent one sample of mineralized quartz vein (SL-1) and one sample of rusty-weathered wallrock (SL-2). The two samples were analyzed by inductively coupled argon plasma atomic absorption spectrophotometry (ICP-AAS) after a partial HNO_3-HCl digestion. Geochemical data for vegetation samples are presented in Part 1 of

Appendix I. Part 2 contains the lower limits of detection for each element in the NAA vegetation package.

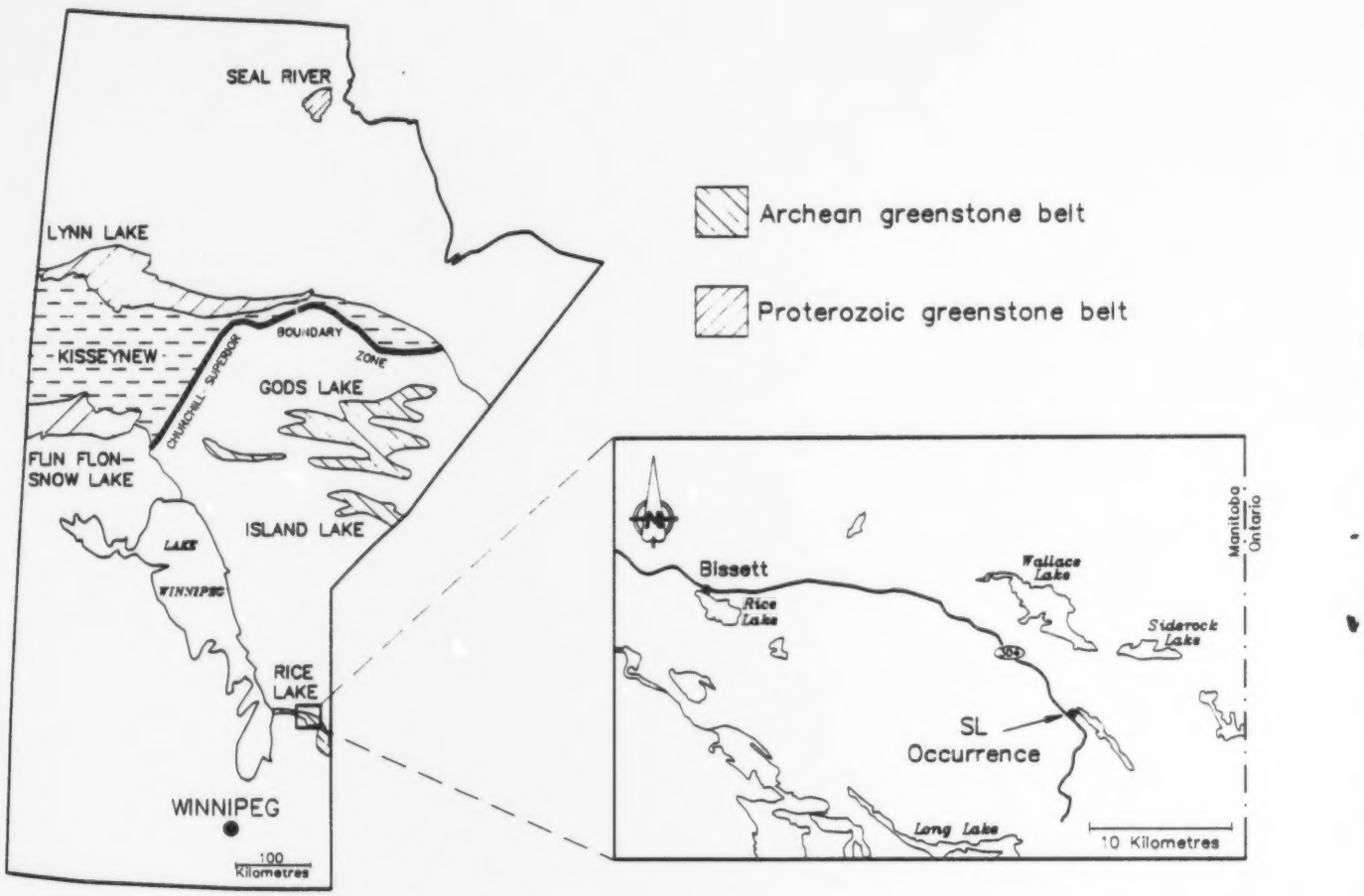


Figure 1: Location map for the black poplar study area, SL occurrence, Bissett area, southeastern Manitoba.

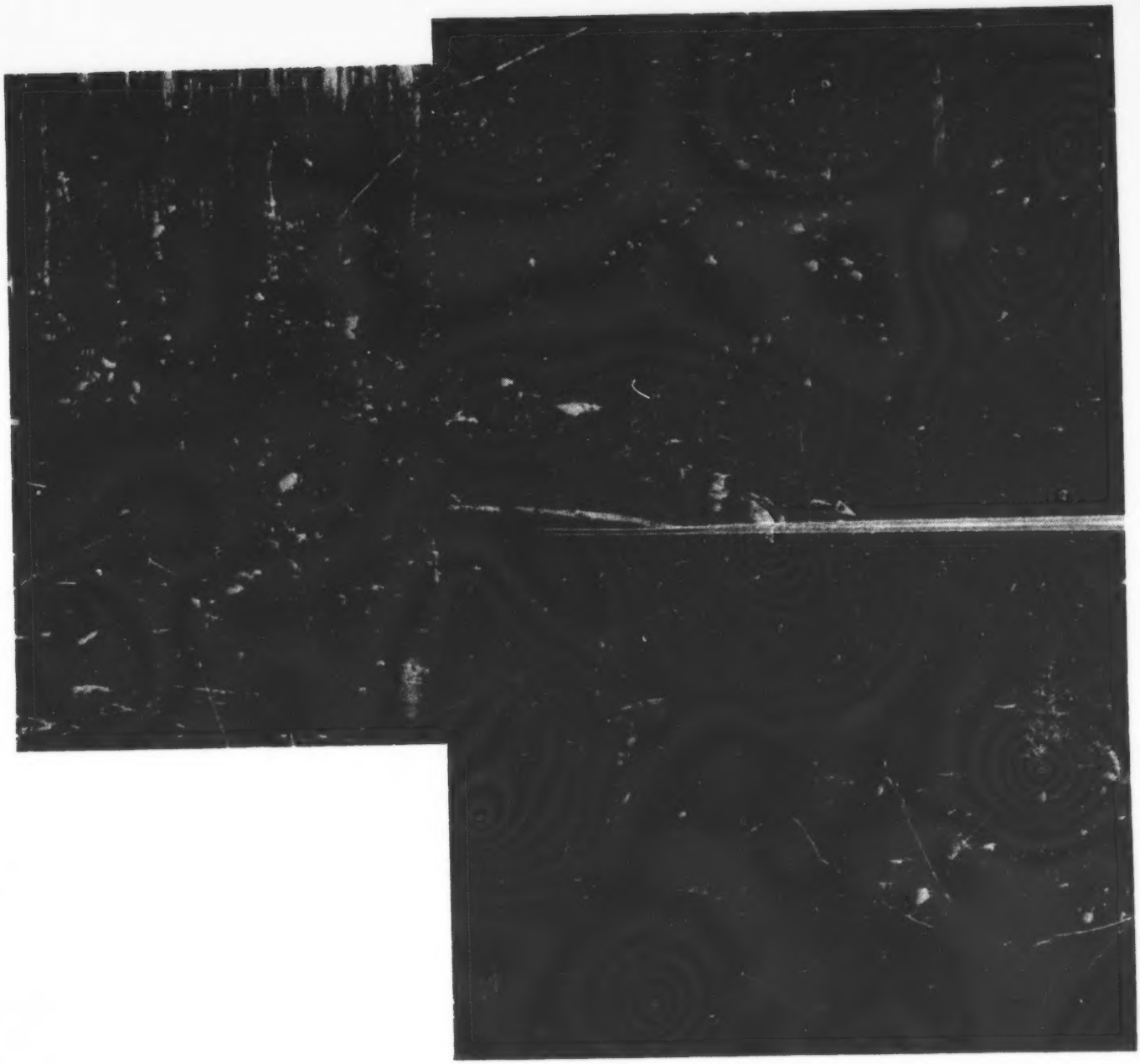
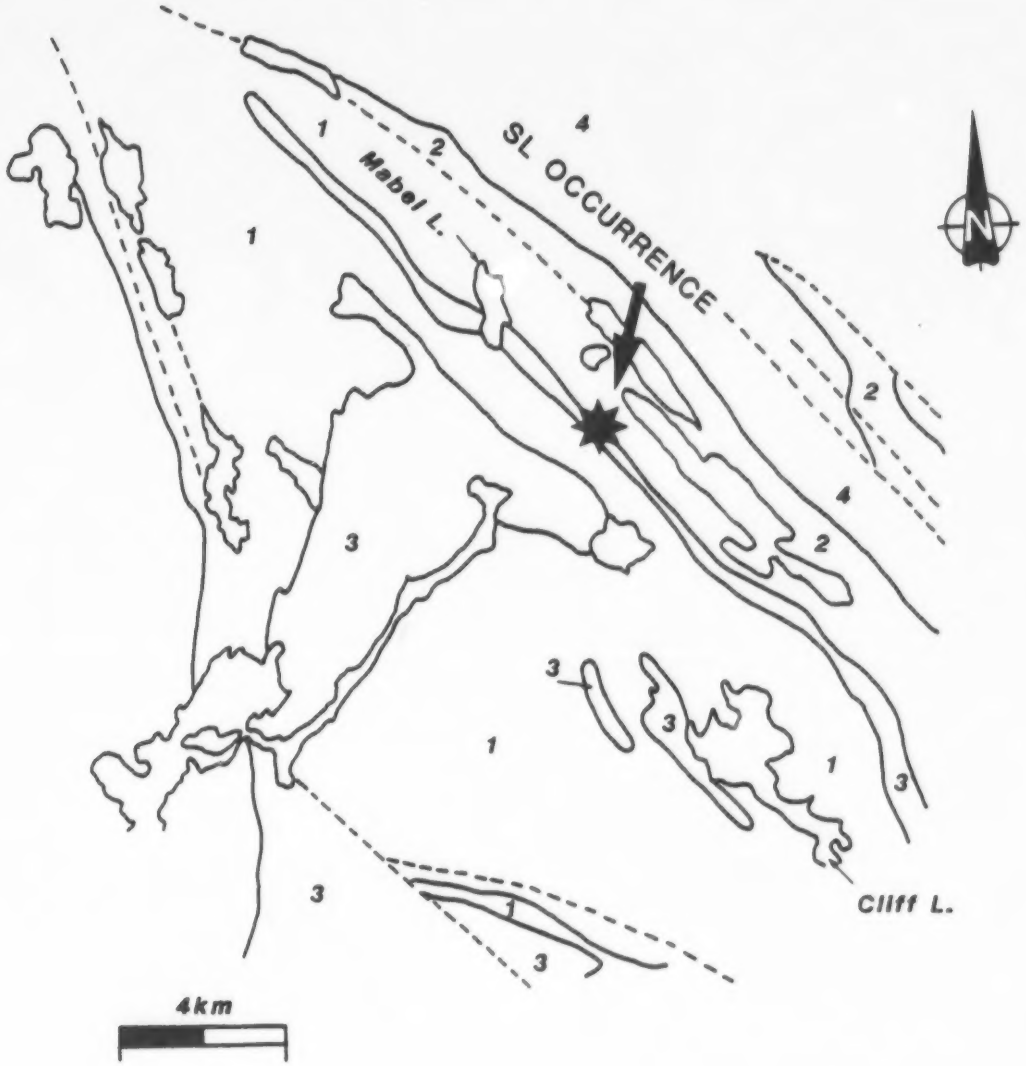


Figure 2: Vegetation and soil profiles in the study area. 2a and 2b illustrate the abundance and nature of *Populus balsamifera L.* (i) growing in the burnt area. 2c illustrates the upper humus and forest litter soil horizon (ii) underlain by dense grey lacustrine clay (iii).



1 Bidou Lake Subgroup

2 Edmunds Lake Formation

3 Mafic intrusions (mainly diabase)

4 Wanipigow River Plutonic Complex

----- Fault

——— Geological contact

Figure 3: General geology in the vicinity of the study area, (after Weber, 1971)

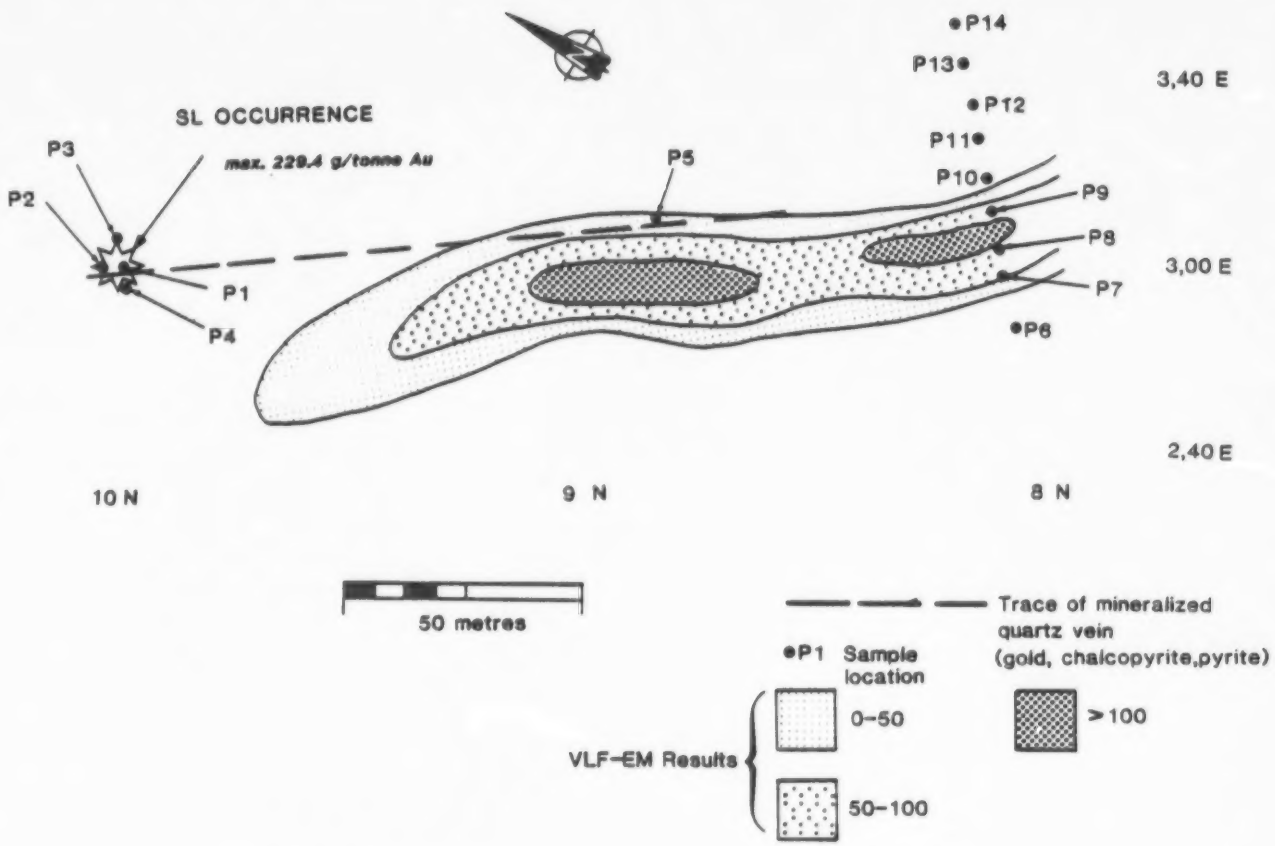


Figure 4: Black poplar (*Populus balsamifera L.*) crown sample locations, SL occurrence, Bissett area. VLF-EM results filtered and contoured at 0-50%, 50-100% and >100%.

RESULTS

Multi-element NAA of the 14 black poplar samples indicates that the elements Ag, Hg, Ir, Mo, Ni, Sc, Se, Sr, Ta, Th, U, W, Nd, Sm, Eu, Tb, Yb and Lu are close to or below the lower limit of detection (LLD) for the analytical method and accordingly are not mentioned further in this report. Descriptive statistical summaries of results from the remaining elements for 1) the entire 14 black poplar crown samples, 2) five black poplar crown samples collected in proximity to the mineralized quartz vein, and 3) nine black poplar crown samples collected away from mineralization, are presented in Tables 1, 2 and 3.

The relative abundance levels of the elements in the black poplar crowns are as follows:

Ca>K>Fe>Zn>Rb>Ba>Cu>Na>Co>As>Br>Cr>Cs>La>Au

Ca ($\bar{X}$ = 20.9%) and K ($\bar{X}$ = 20.2%) are by far are the most abundant elements in the plant ash.

Examination of Tables 2 and 3 indicates a suite of elements that are either enriched or depleted in the five proximal samples when compared to the nine background samples; these diagnostic elements are Ba, Co, Cs, Fe, Na, Zn and La. All elements except Zn are enriched in the proximal samples. As is enriched in three of five proximal samples. These variations are presented graphically in Figures 5 to 25. For ease of inspection, the diagnostic elements and their descriptive statistics are presented for both mineralized and background samples in Table 4.

Of the seven diagnostic elements Ba, Co and Cs are the best discriminators of proximal and background poplars. The elements Ba, Co and Cs are characterized by two to five-fold increases in concentration in the proximal poplar samples versus those representing background (Table 4). Additionally, there is no overlap in concentration ranges for Ba, Co and Cs between the two sample groups. Variation diagrams utilizing these three elements attain excellent separation of the two data populations (Figures 5 to 25). Histograms for these three elements indicate distinct data populations at the "tail" of a positively skewed distribution (Fig. 26). The contrast for Fe, Na, Zn, La and As is low, i e. proximal and background samples have similar concentration ranges (Tables 2 and 3). Histograms for Na, As and Fe are presented in Figure 27 and for Zn and La in Figure 28.

There is virtually no correspondence between the element content of ashed plant tissues and rock samples representing vein material and wall rock, although anomalous concentrations of Au (2480 and 12190 ppb), Cu (242 and 244 ppm), Fe (5.12 and 7.32%) and Ni (27 and 110 ppm) are present in the mineralized zone (Table 5). There is a possible or weak correspondence in Fe contents of the poplar crowns sampled adjacent to the mineralization (0.08-0.17% versus 0.05-0.09% Fe for background poplars). Ba, the most efficient discriminator between proximal poplars and background poplars, is present in minor quantities in both the mineralized quartz vein and the rusty-weathered wallrock (both 12 ppm).

TABLE 1

Descriptive statistics for geochemical data from 14 black poplar crown samples.

ELEMENT	ARITHMETIC MEAN	STANDARD DEVIATION	RANGE
Au(ppb)	9.1	2.5	5.0 - 14.0
As(ppm)	7.4	3.3	3.5 - 13.0
Ba(ppm)	311	172	110 - 690
Br(ppm)	7.3	2.3	4.0 - 12.0
Ca(%)	20.9	2.1	15.8 - 24.6
Co(ppm)	11.0	8.8	2.0 - 28.0
Cr(ppm)	4.5	1.1	3.0 - 6.0
Cs(ppm)	2.0	1.9	0.5 - 5.5
Cu(ppm)	257	53	171 - 362
Fe(%)	0.08	0.03	0.05 - 0.17
K (%)	20.2	1.7	17.9 - 24.5
Na(ppm)	168	36	121 - 219
Rb(ppm)	533	151	360 - 850
Zn(ppm)	2036	369	1600 - 3000
La(ppm)	1.0	0.8	0.3 - 2.9

TABLE 2

Summary of descriptive statistics for analytical data representing 5 black poplar samples collected in proximity to the mineralized quartz vein.

ELEMENT	ARITHMETIC MEAN	STANDARD DEVIATION	RANGE
Au(ppb)	9.4	2.6	6.0 - 13.0
As(ppm)	8.9	3.9	4.2 - 12.0
Ba(ppm)	504	114	396 - 690
Br(ppm)	8.8	1.9	7.0 - 12.0
Ca(%)	19.7	2.4	15.8 - 21.9
Co(ppm)	21	6	13 - 28
Cr(ppm)	5.2	1.1	4.0 - 6.0
Cs(ppm)	4.1	1.6	1.8 - 5.5
Cu(ppm)	251	61	187 - 351
Fe(%)	0.11	0.04	0.08 - 0.17
K (%)	20.0	1.4	18.0 - 21.5
Na(ppm)	204	13	191 - 219
Rb(ppm)	548	155	360 - 770
Zn(ppm)	1820	84	1700 - 1900
La(ppm)	1.84	0.73	1.00 - 2.90

TABLE 3

Summary of descriptive statistics for analytical data representing nine black poplar samples collected 150 m from the mineralized quartz vein.

ELEMENT	ARITHMETIC MEAN	STANDARD DEVIATION	RANGE
Au(ppb)	8.9	2.6	5.0 - 14.0
As(ppm)	6.5	2.9	3.5 - 13.0
Ba(ppm)	203	74	110 - 310
Br(ppm)	6.4	2.1	4.0 - 11.0
Ca(%)	21.5	1.8	19.3 - 24.6
Co(ppm)	5	3	2 - 9
Cr(ppm)	4.1	0.9	3.0 - 6.0
Cs(ppm)	0.8	0.4	0.5 - 1.6
Cu(ppm)	261	52	171 - 362
Fe(%)	0.07	0.01	0.05 - 0.09
K (%)	20.3	1.9	17.9 - 24.5
Na(ppm)	149	28	121 - 201
Rb(ppm)	524	157	360 - 850
Zn(ppm)	2156	416	1600 - 3000
La(ppm)	0.54	0.21	0.30 - 1.00

TABLE 4

Comparison of descriptive statistics for diagnostic elements in proximal(n = 5) and background(n = 9) black poplar crown analyses.

ELEMENT	ARITHMETIC MEAN	STANDARD DEVIATION	RANGE
Ba(ppm)1.	504	114	396 - 690
2.	03	74	110 - 319
Co(ppm)1.	21	6	13 - 28
2.	5	3	2 - 9
Cs(ppm)1.	4.1	1.6	1.8 - 5.5
2.	0.8	0.4	0.5 - 1.6
Fe(%) 1.	0.11	0.04	0.08 - 0.17
2.	0.07	0.01	0.05 - 0.09
Na(ppm)1.	204	13	191 - 219
2.	149	28	121 - 201
Zn(ppm)1.	1820	84	1700 - 1900
2.	2156	416	1600 - 3000
La(ppm)1.	1.84	0.73	1.00 - 2.90
2.	0.54	0.21	0.30 - 1.00
As(ppm)1.	8.9	3.9	4.2 - 12.0
2.	6.5	2.9	3.5 - 13.0

Note: 1.- Proximal
2.- Background

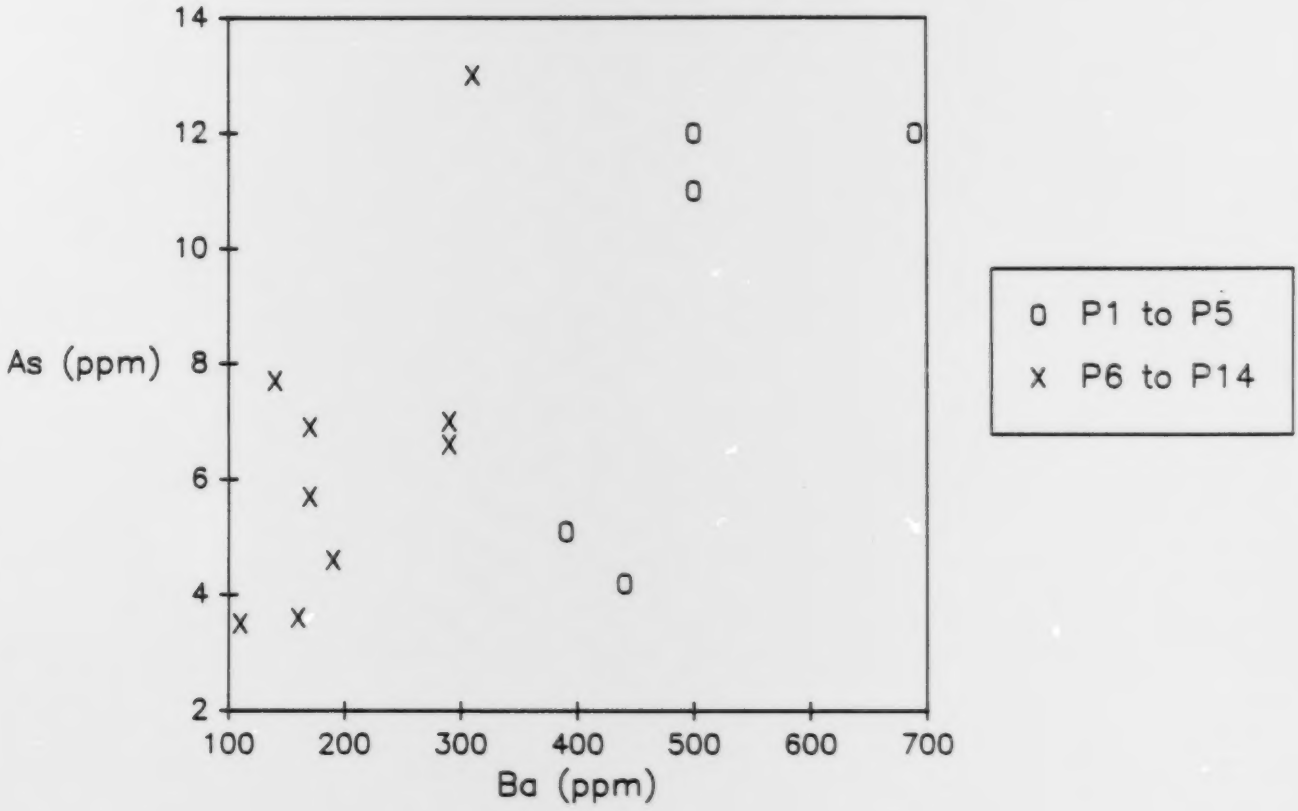


Figure 5: As-Ba variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

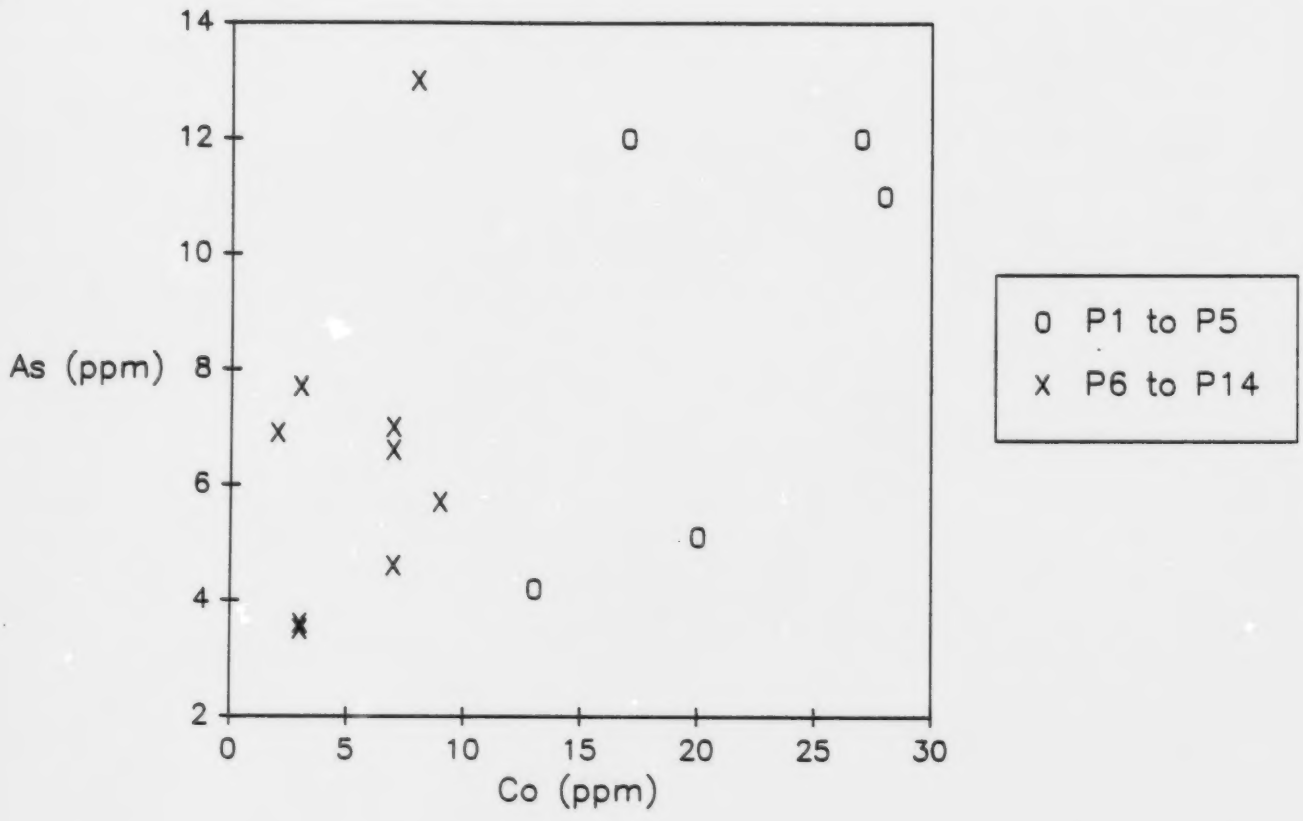


Figure 6: As Co variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

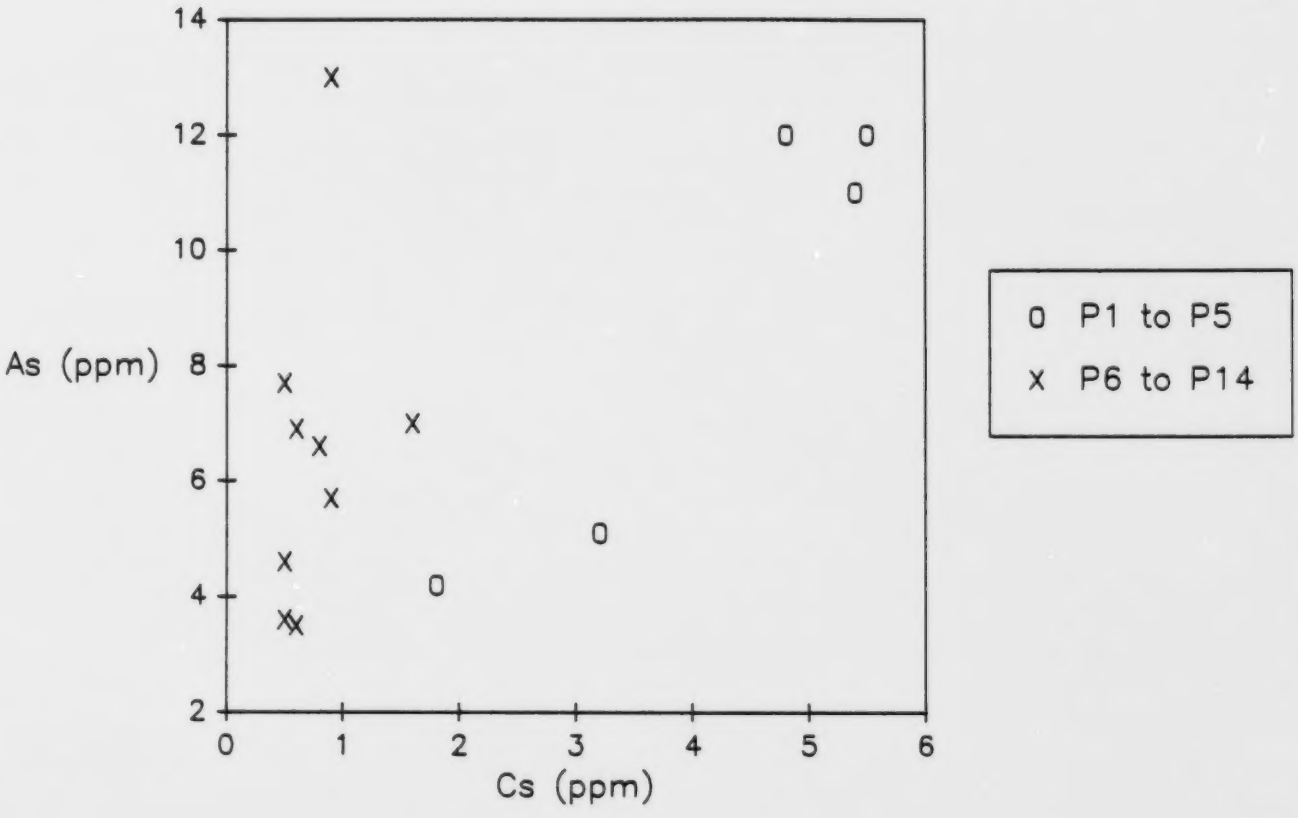


Figure 7: As-Cs variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

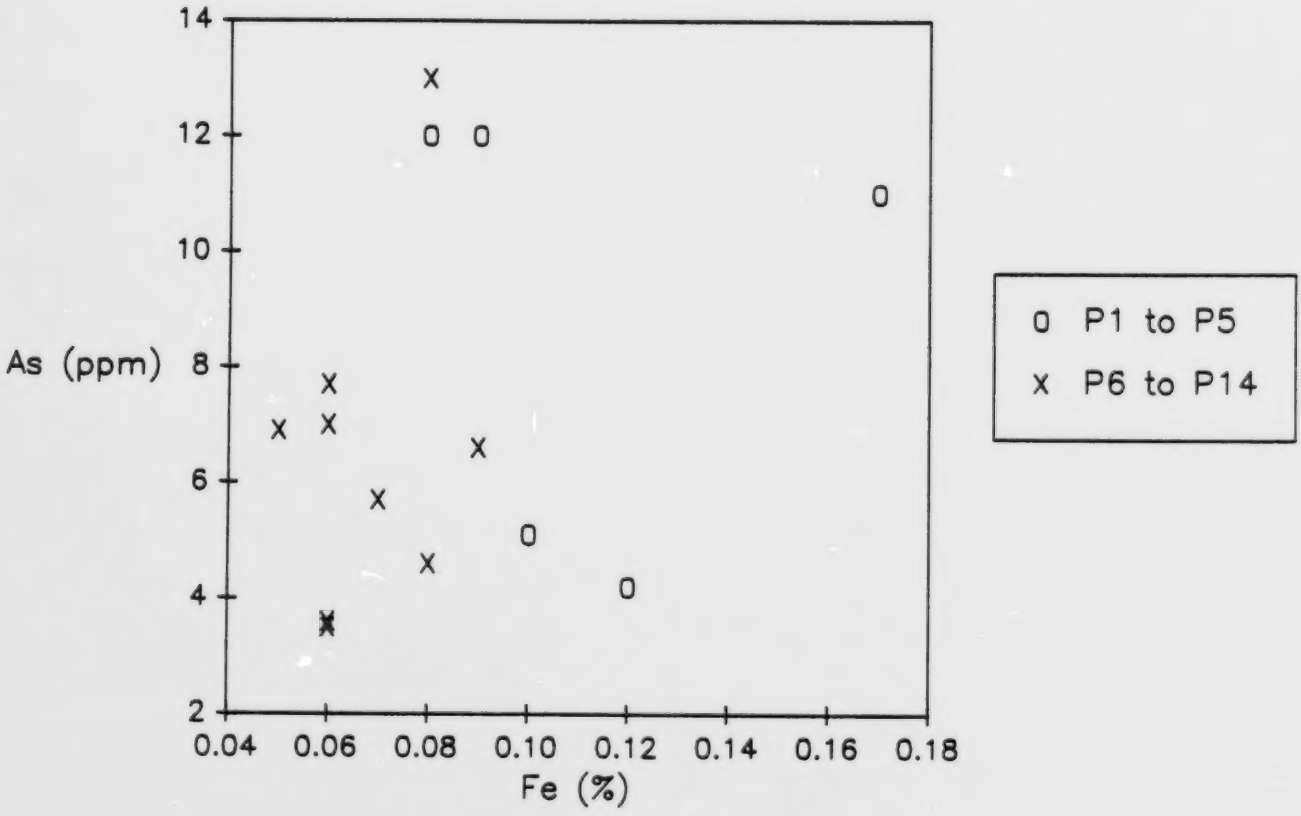


Figure 8: As-Fe variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

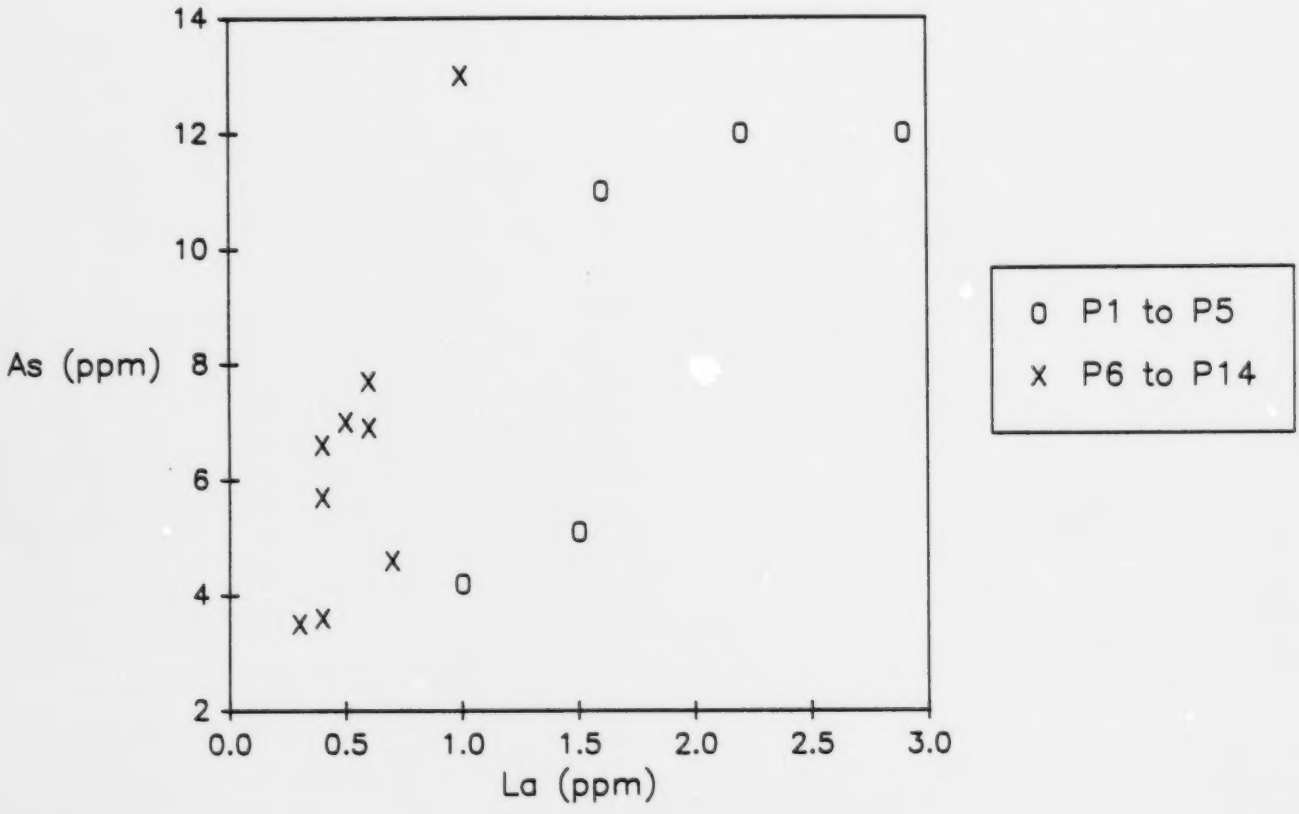


Figure 9: As-La variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

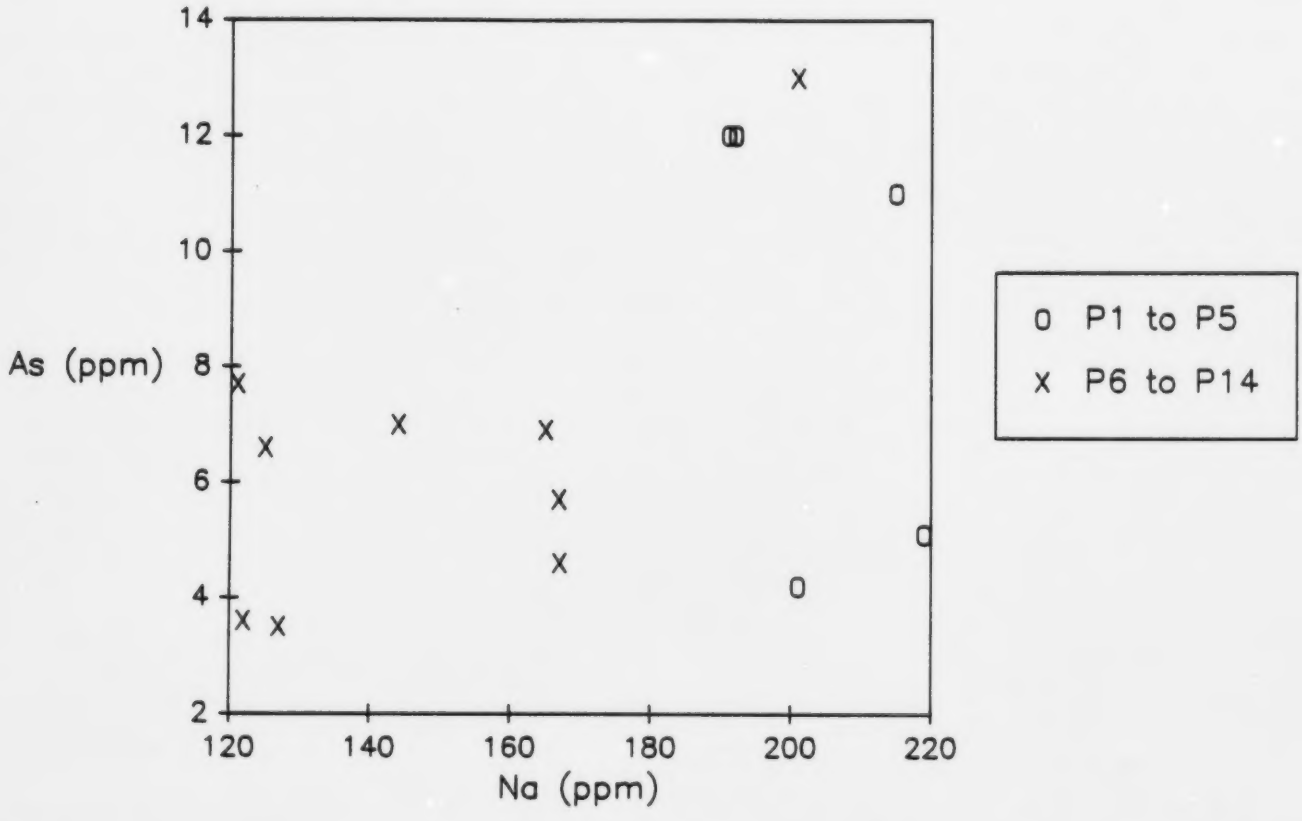


Figure 10: As-Na variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

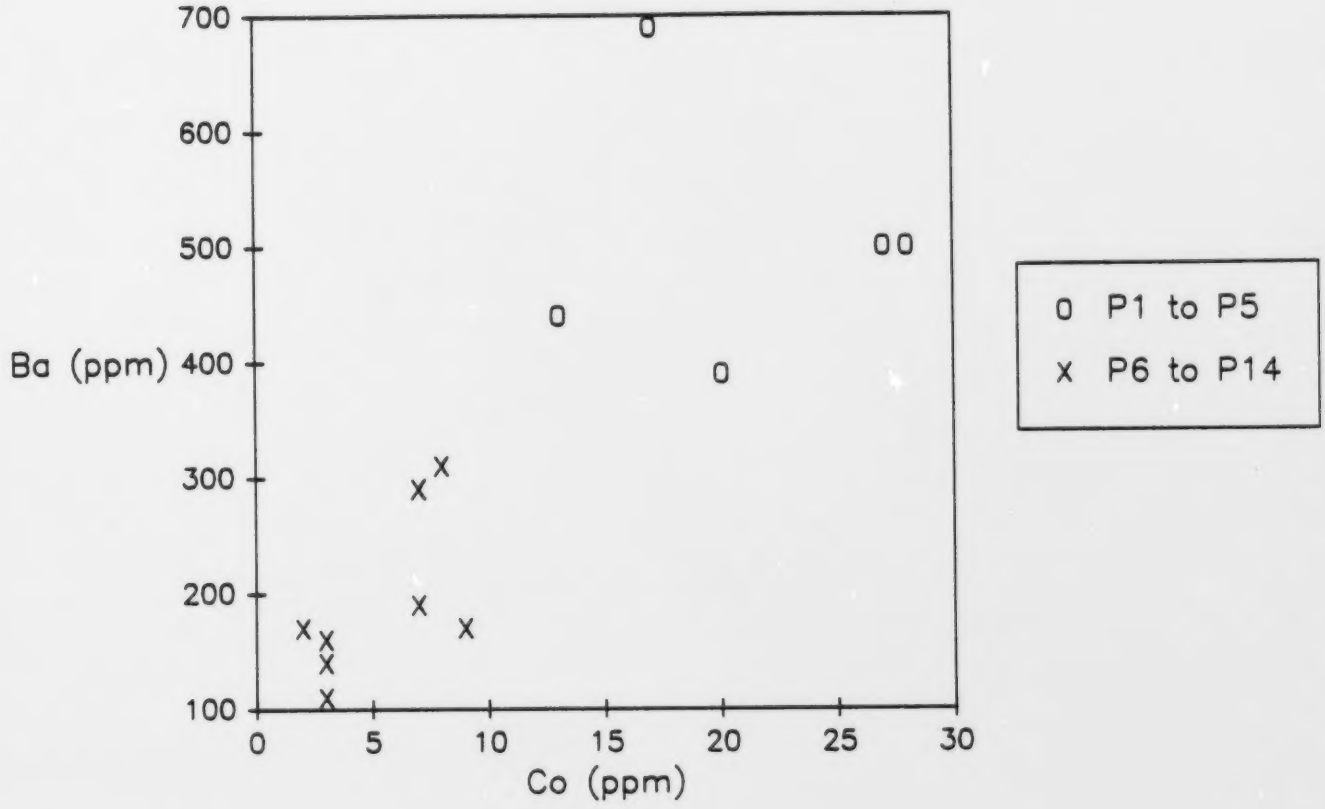


Figure 11: Ba-Co variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

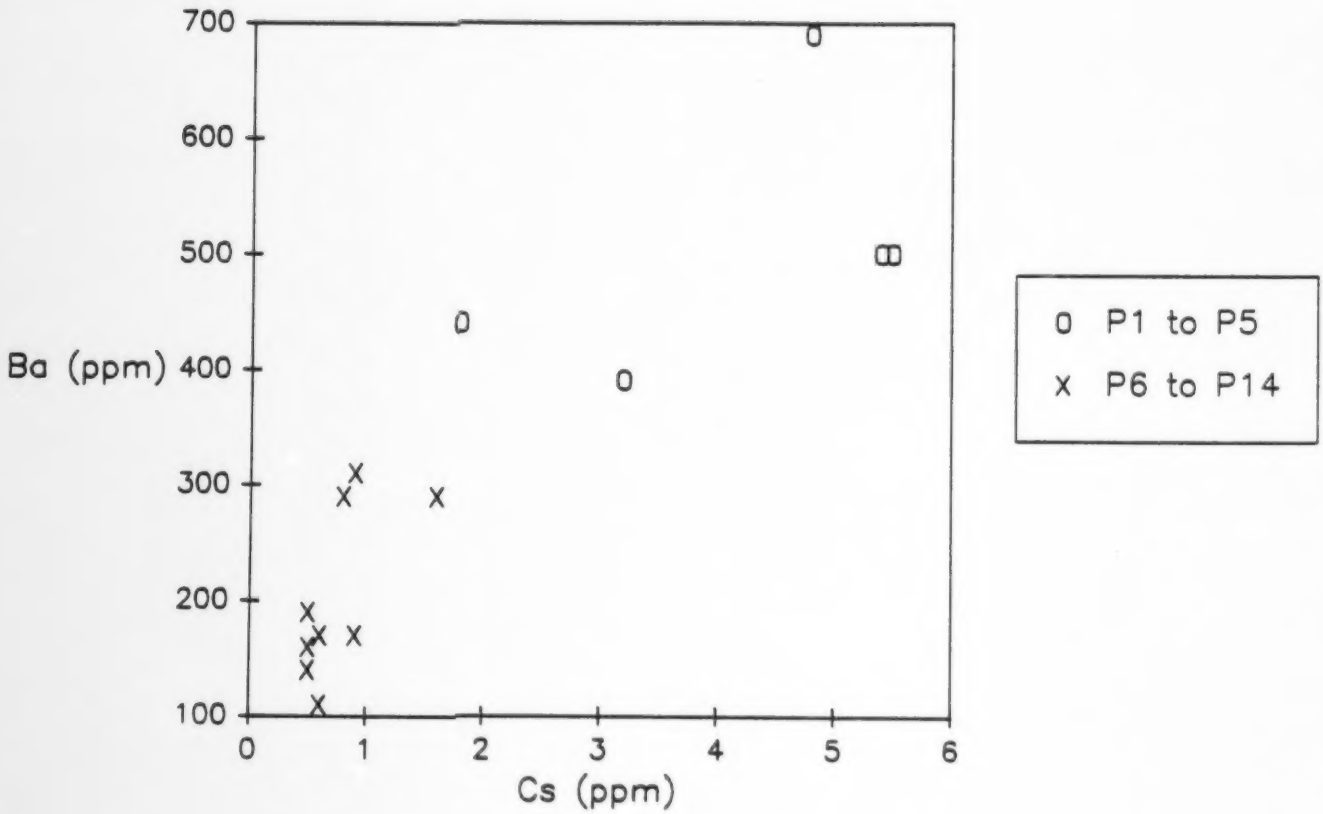


Figure 12: Ba-Cs variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

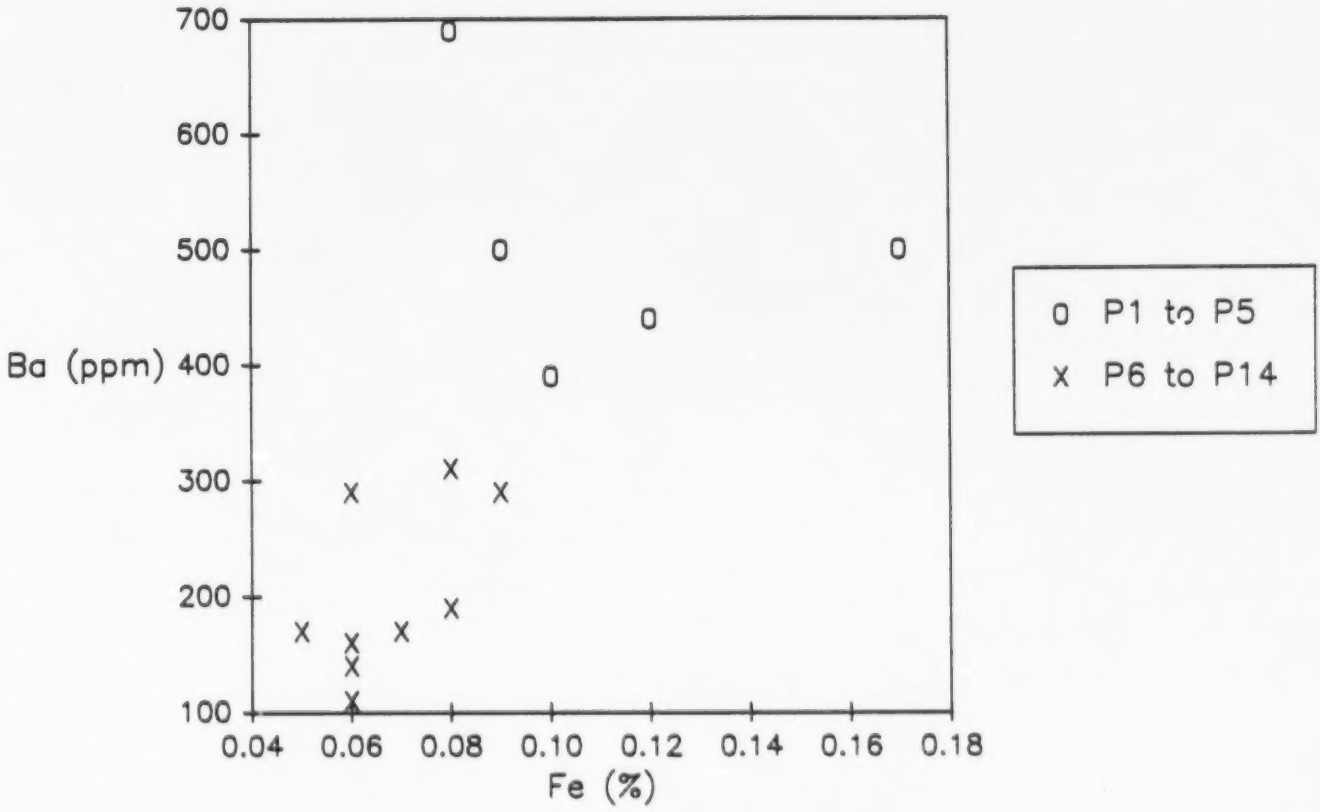


Figure 13: Ba-Fe variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

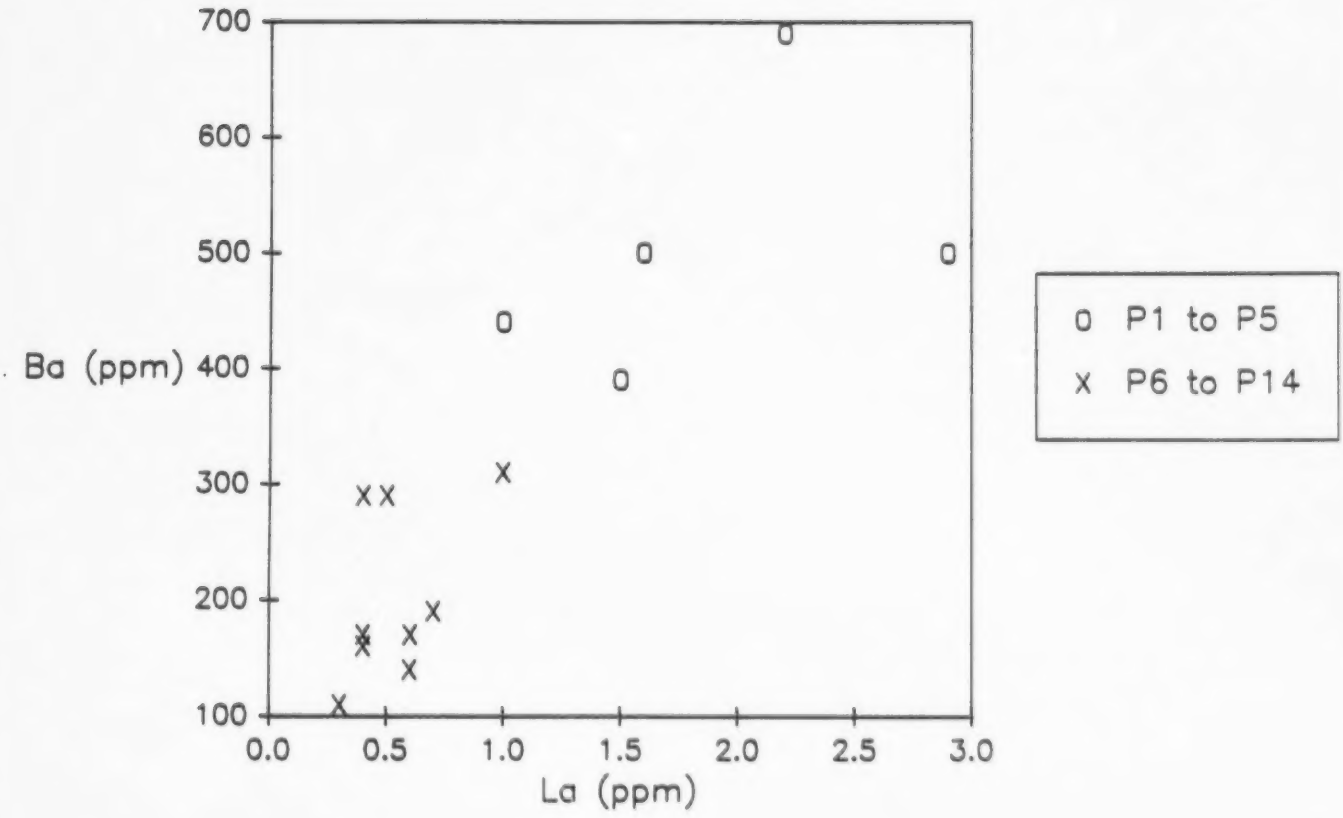


Figure 14: Ba-La variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

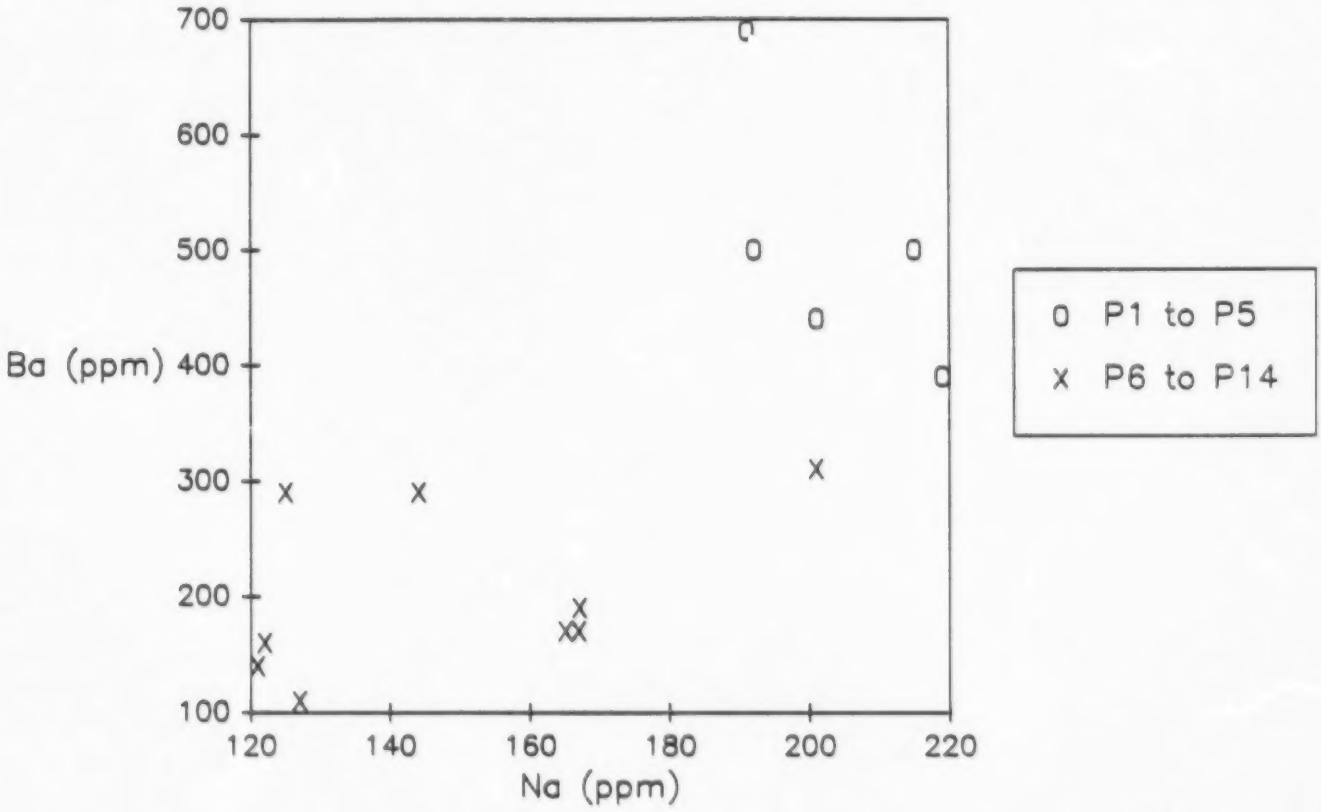


Figure 15: Ba-La variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

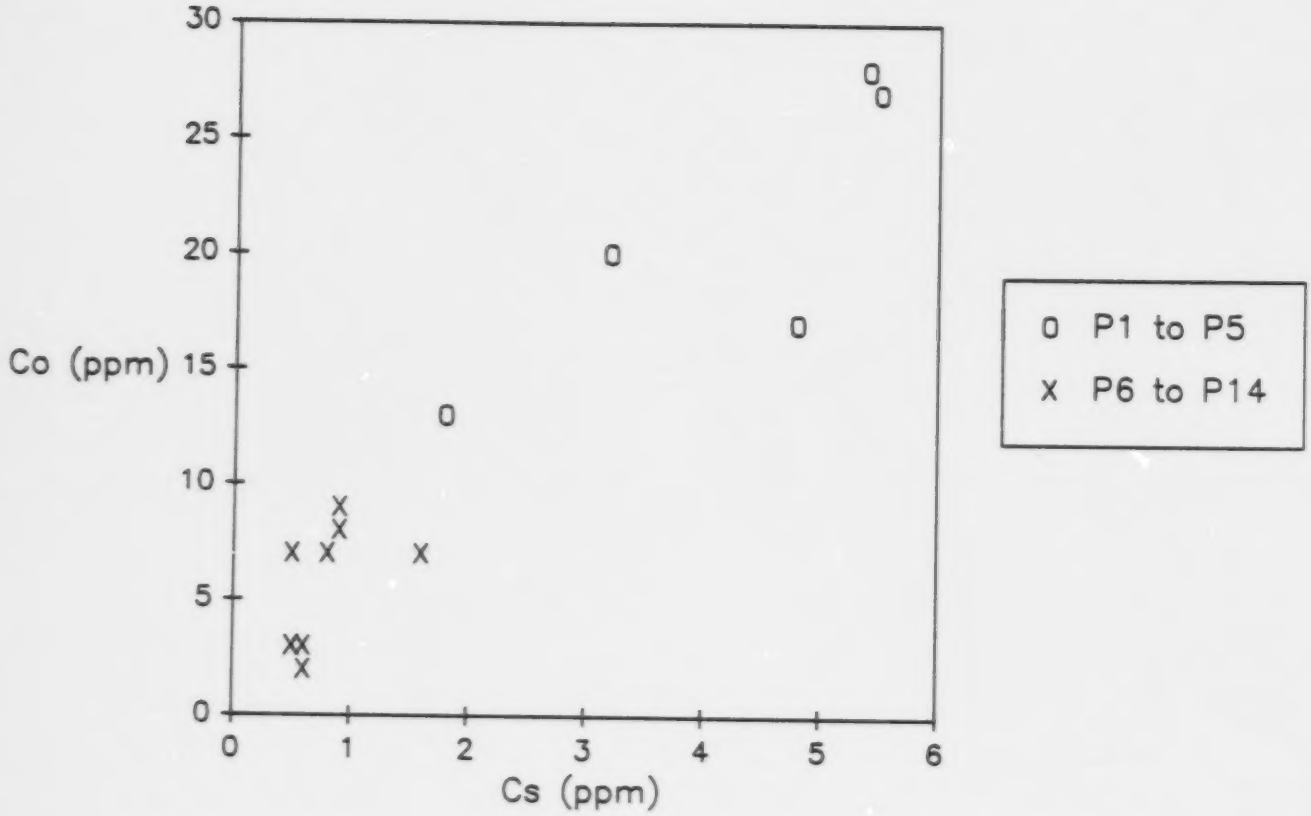


Figure 16: Co-Cs variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

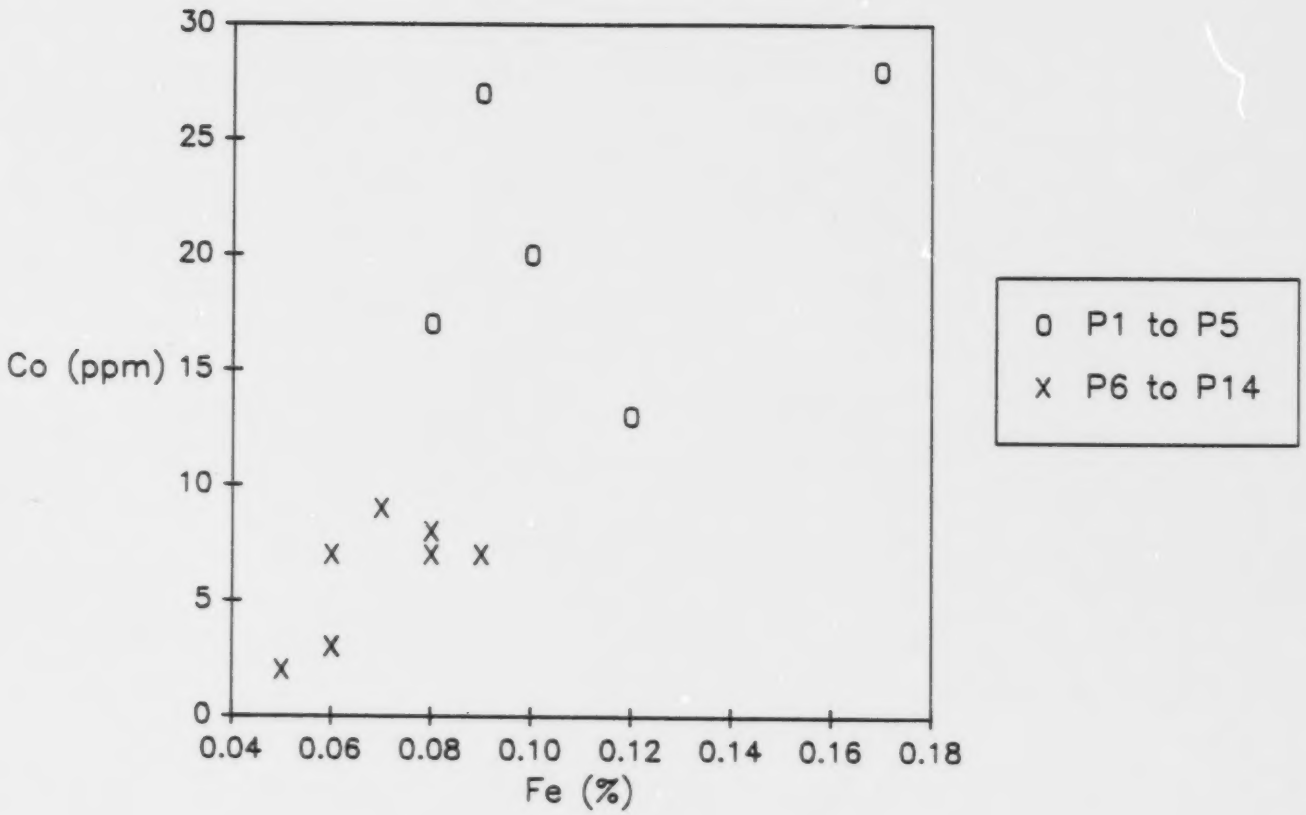


Figure 17: Co-Fe variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

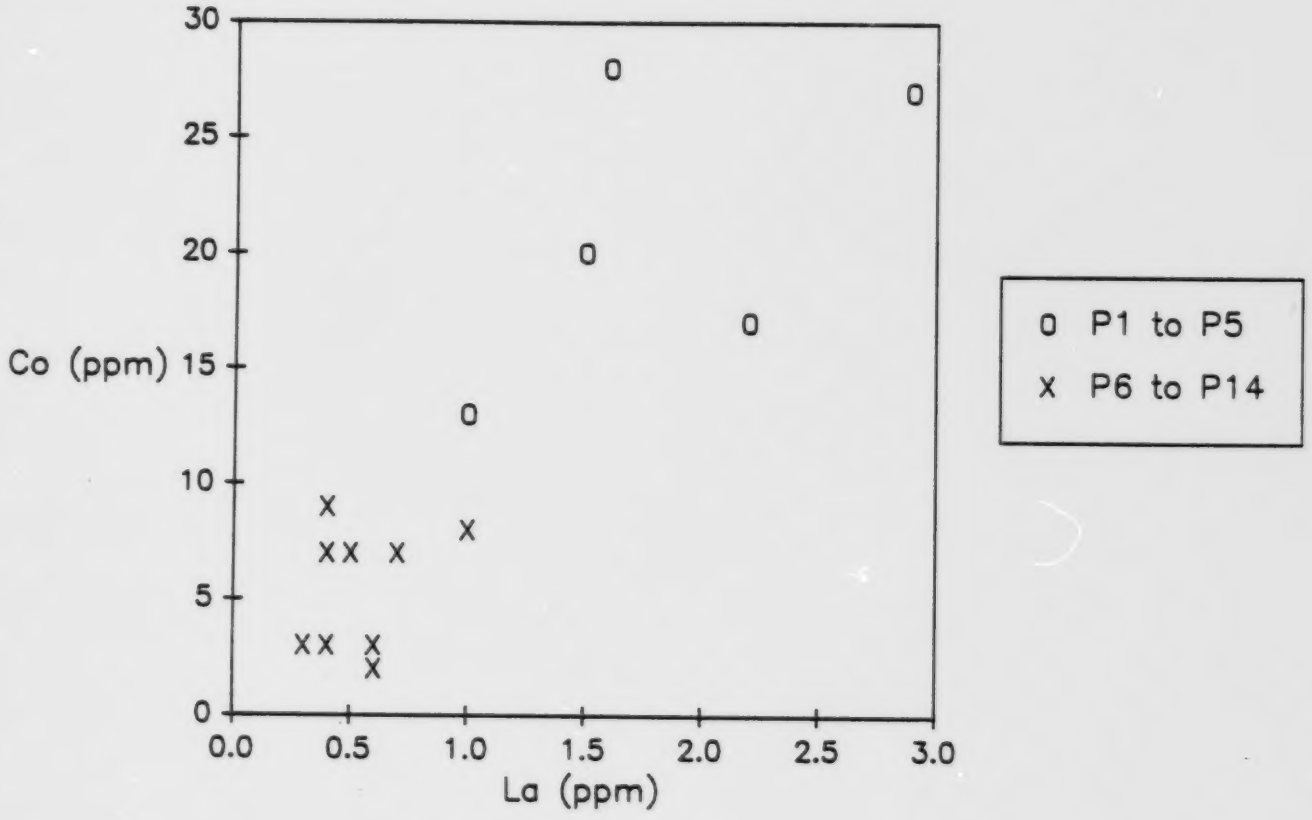


Figure 18: Co-La variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

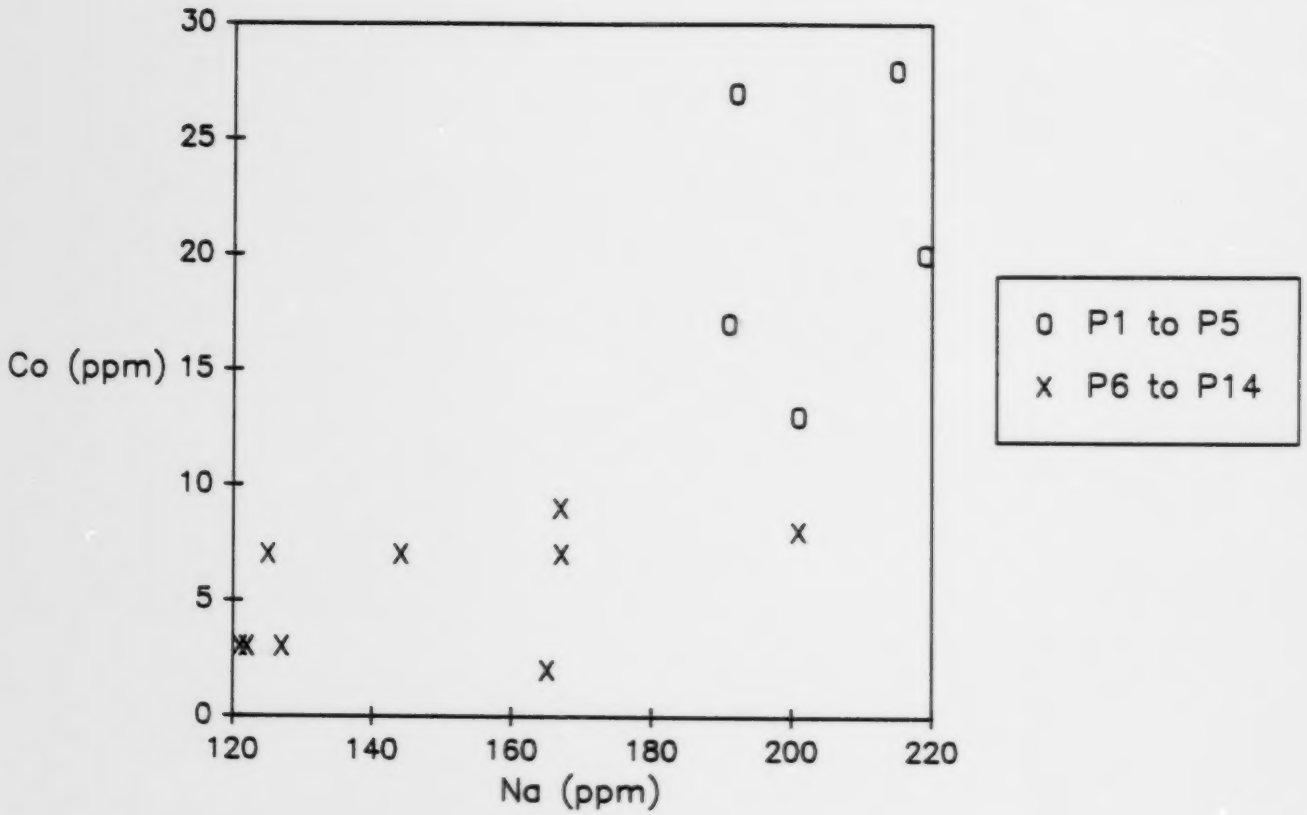


Figure 19: Co-Na variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

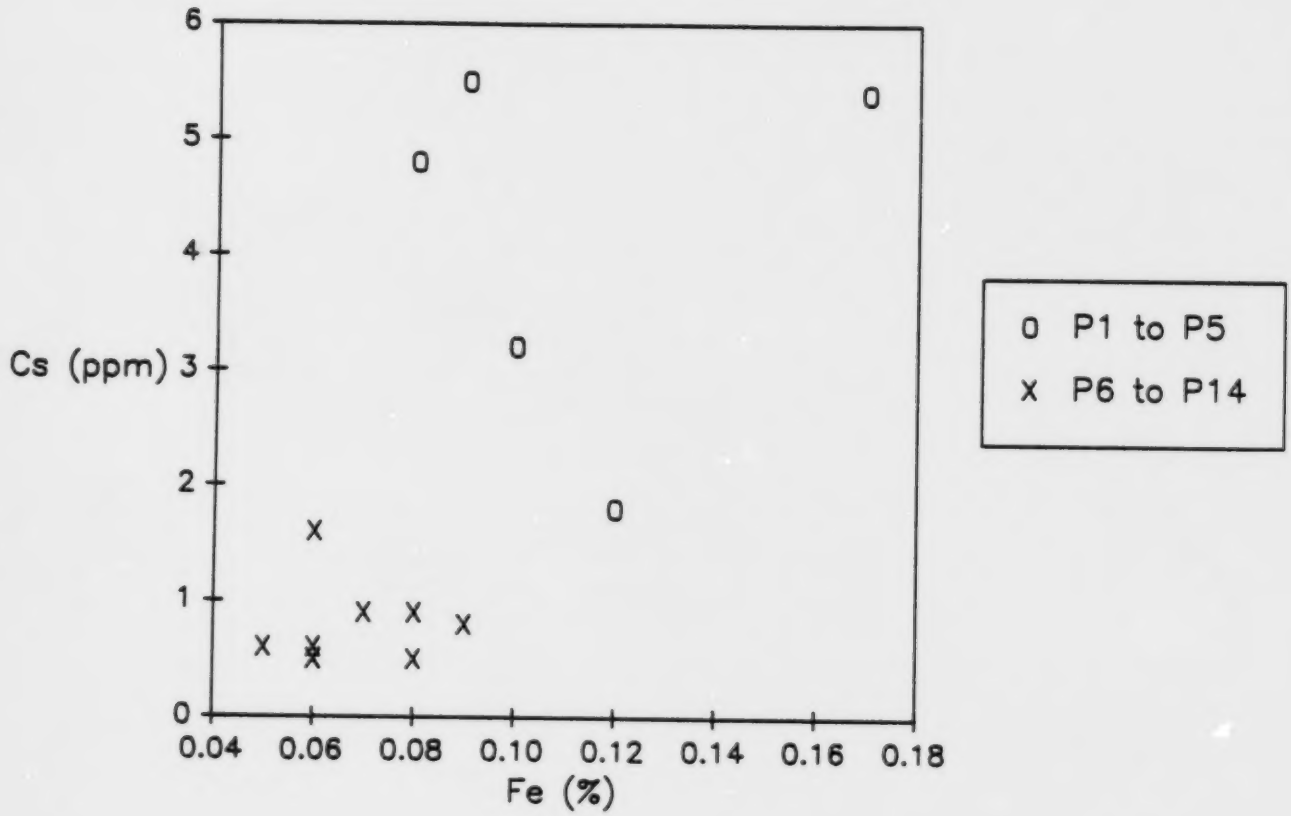


Figure 20: Cs-Fe variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

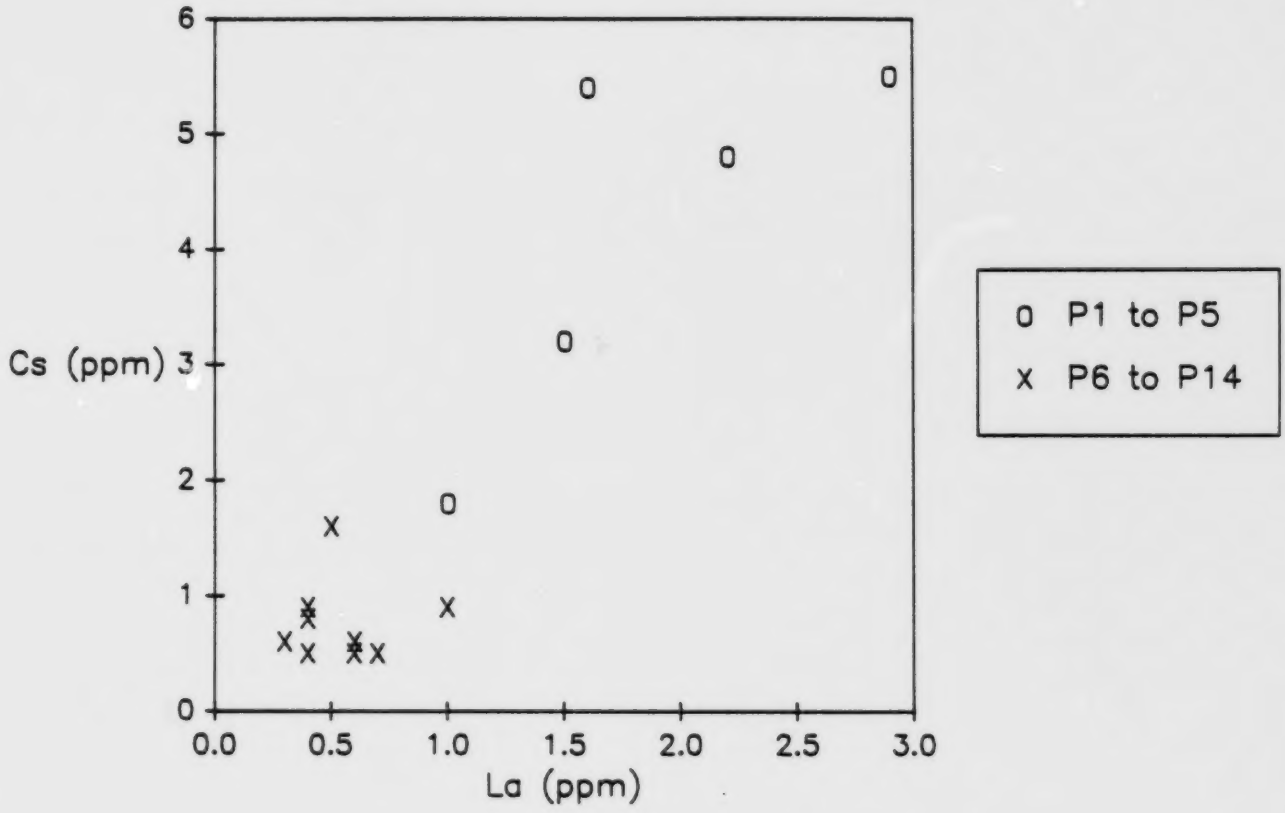


Figure 21: Cs-La variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

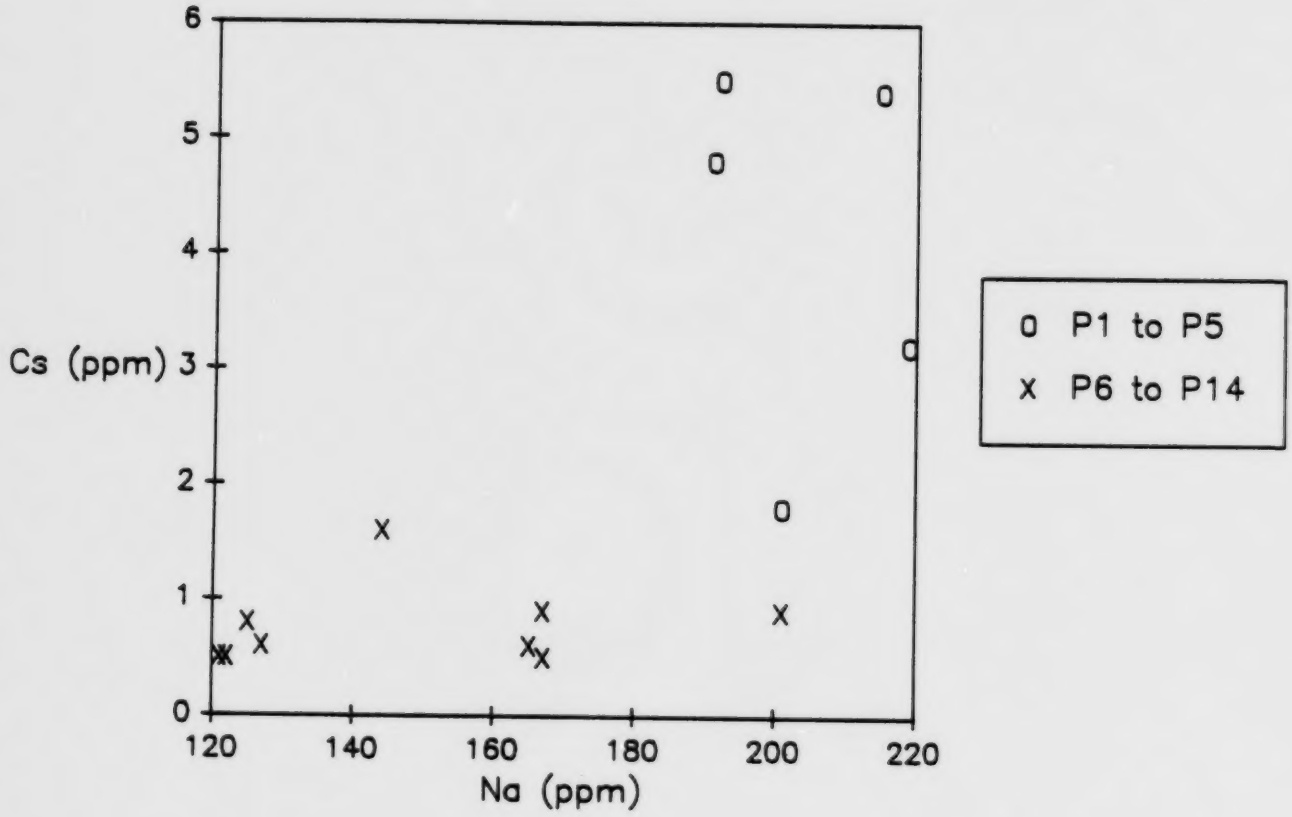


Figure 22: Cs-Na variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

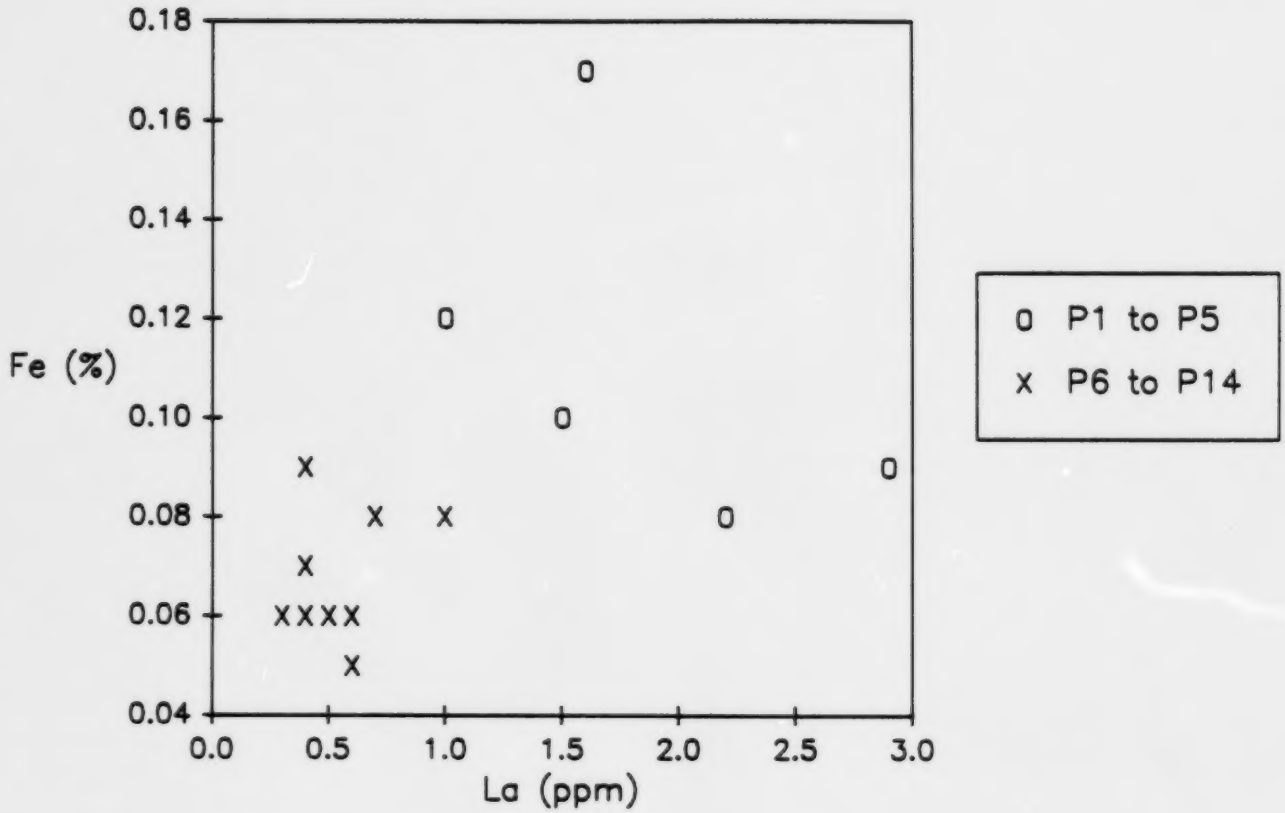


Figure 23: Fe-La variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

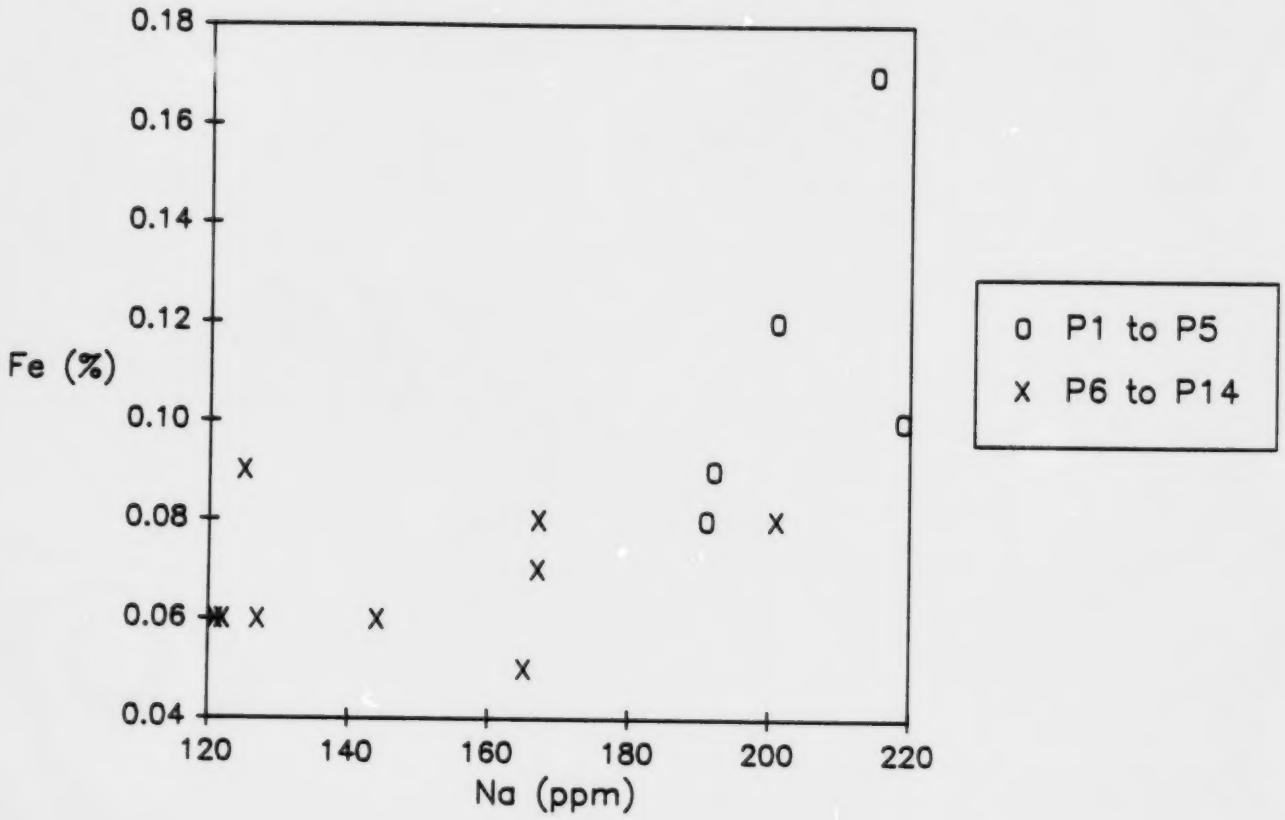


Figure 24: Fe-Na variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

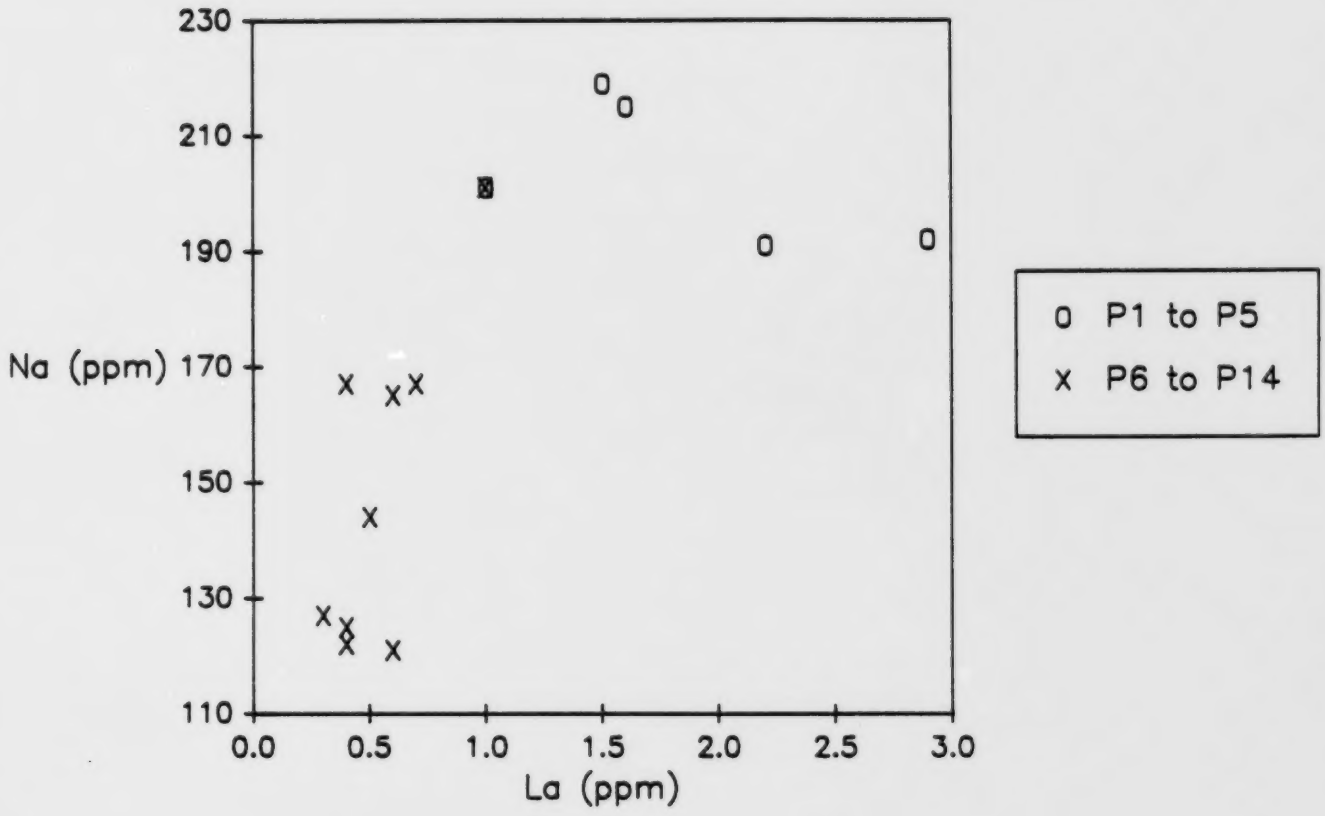


Figure 25: Na-La variogram for black poplar crowns, SL deposit, Bissett area. P1 to P5 represent black poplar samples collected near the mineralized quartz vein and P6 to P14 represent background samples.

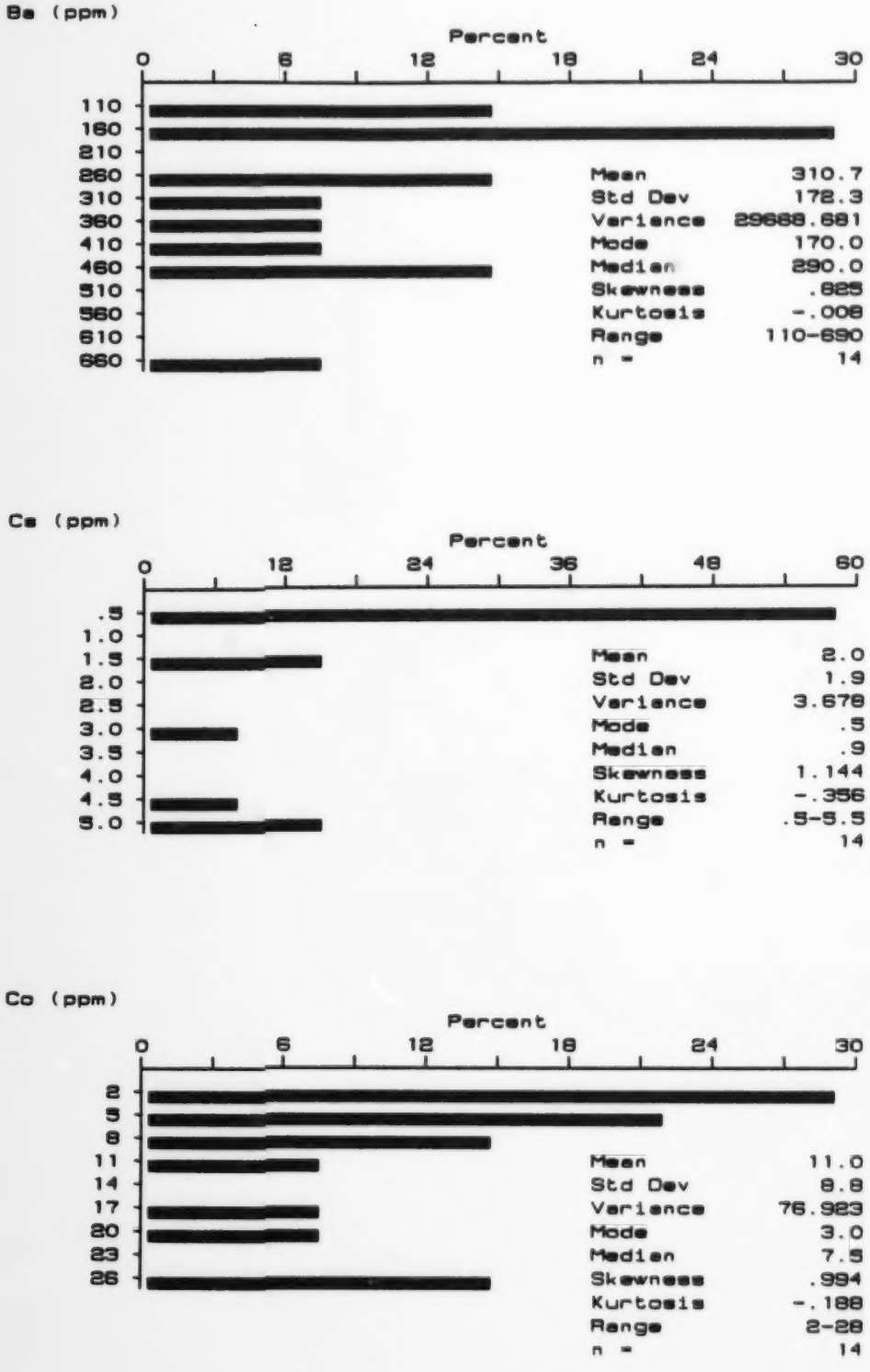


Figure 26: Histograms and descriptive statistics for Ba, Cs and Co in ashed black poplar crowns, SL deposit.

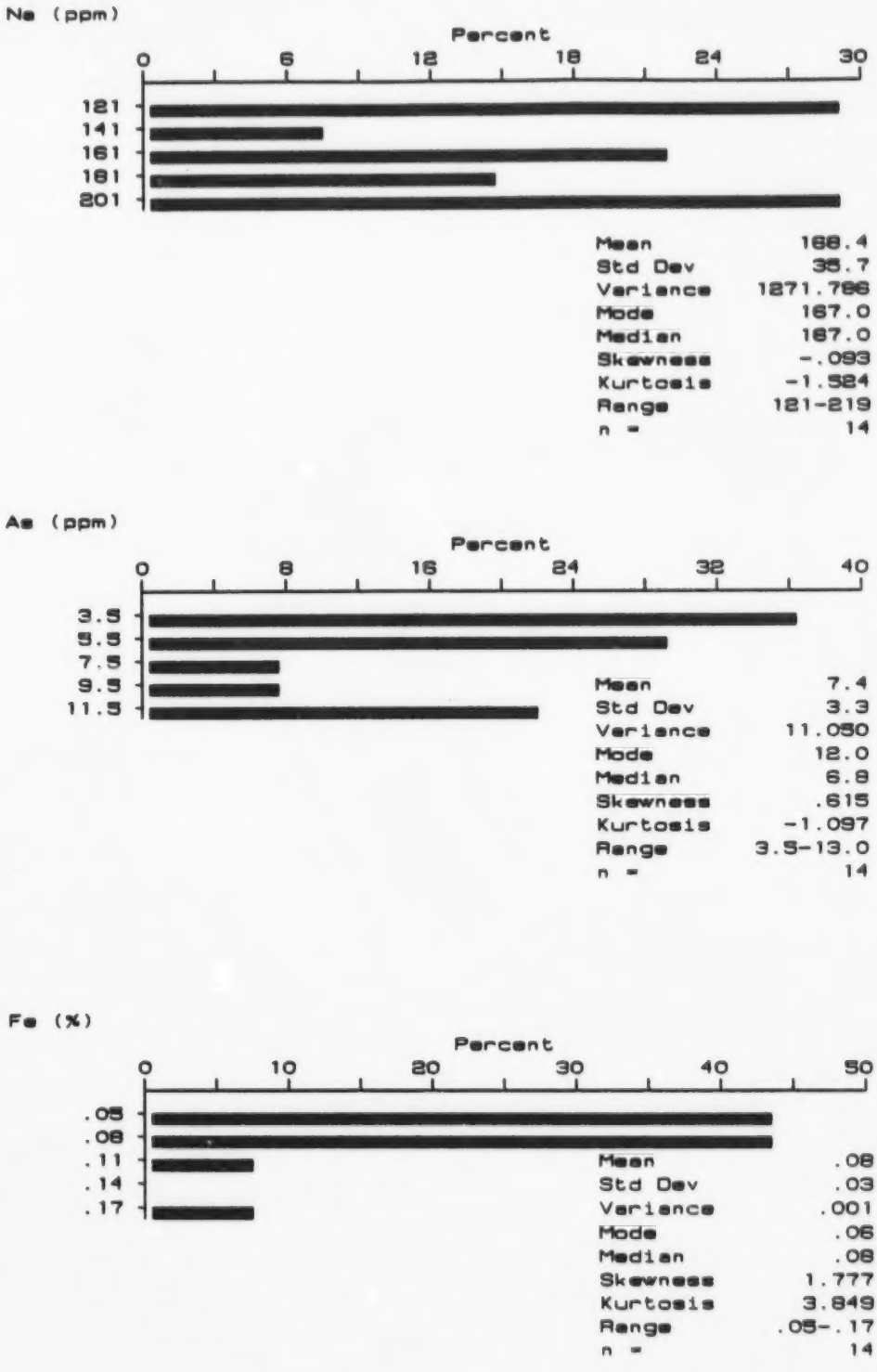


Figure 27: Histograms and descriptive statistics for Na, As and Fe in ashed black poplar crowns, SL deposit.

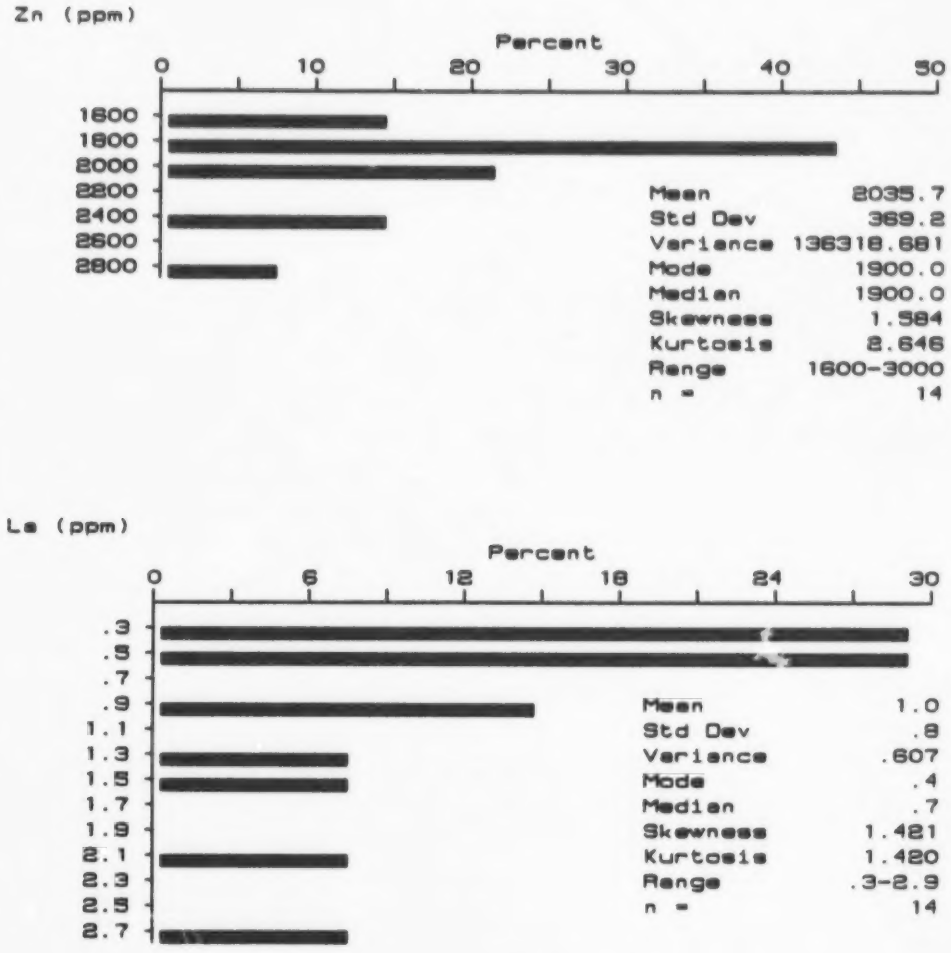


Figure 28: Histograms and descriptive statistics for Zn, and La in ashed black poplar crowns, SL deposit.

TABLE 5

Summary of geochemical data from the ICP-AAS analysis of two rock samples from the SL occurrence. Analysis was undertaken after a 0.500 g sample is digested partially with a 3-1-2 HCl-HNO_3-H_2O mixture. This leach is partial for Mn, Fe, Sr, Ca, P, La, Cr, Mg, Ba, Ti, B, W, Na, K and Al. All elements in ppm unless otherwise noted.

ELEMENT	SL-1(Quartz Vein)	SL-2(Wall rock)
Mo	3	4
Cu	244	242
Pb	2	2
Zn	15	41
Ag	1.0	0.4
Ni	27	110
Co	6	17
Mn	88	323
Fe(%)	7.32	5.12
As	23	10
U	5	5
Th	1	1
Sr	11	13
Cd	1	1
Sb	3	2
Bi	2	3
V	12	28
Ca(%)	0.36	1.06
P (%)	0.037	0.05
La	2	6
Cr	15	30
Mg(%)	0.21	0.92
Ba	12	12
Ti(%)	0.07	0.03
B	4	2
Al(%)	0.47	1.43
Na(%)	0.01	0.05
K (%)	0.07	0.07
W	7	3
Au(ppb)	12190	2480

DISCUSSION AND CONCLUSION

Although negligible vegetation geochemical information is available from species representing the reforestation process in burned boreal forest, the uptake of elements such as Ba, Co and Cs in a wide range of vegetation has been reported in the literature. Recently, Dunn and Hoffman (1986) describe the results of a multi-element and multi-media vegetation geochemical survey undertaken in proximity to near surface zones of allanite-rich mineralization in northern Saskatchewan. In the absence of rock geochemical haloes, they describe elevated concentrations of La, Ce and Sm in alder twigs and leaves and Ba and Sr in alder twigs from one locality. In addition, at a second nearby study area, consisting of a trenched occurrence of allanite, apatite and hyalophane, elevated concentrations of rare-earth elements were identified in labrador tea twigs and roots, and birch twigs, trunk and outer bark. A grid sampling program utilizing ubiquitous black spruce over the latter study area revealed the capability of black spruce to absorb and tolerate high concentrations of La, Ce, Ba and Sr in proximity to the mineralized zones.

The extraordinarily high concentration of certain elements in ashed plant samples has been documented by numerous workers and summarized by Brooks (1972). The results of some of these studies are presented in Table 6 (cf. Brooks, 1972, p. 98). In addition, Fedikow (1986) reports narrow, but identifiable Ba depletions in the outer bark of black spruce (*Picea mariana*) growing over an As-Au occurrence in the Lynn Lake area.

Clearly, there exists substantial scientific data supportive of the use of vegetation geochemical surveys in an integrated exploration program. The recognition of elevated concentrations of Ba, Co and Cs in black poplar crowns growing in a burned boreal forest environment adjacent to gold-chalcopyrite-pyrite vein type mineralization in this very brief study is of intrest. These elements are readily analyzed in a cost-effective manner by neutron activation with little or no loss of Ba and Co in the ashing process. Although Cs is volatilized during dry ashing at 475ºC the loss appears to be uniform and constant for a given sample medium (needles, twigs, bark) and should therefore be considered as useful in a vegetation geochemical survey requiring the neutron activation analysis of this element (Dunn and Hoffman, 1986). The ubiquitous growth of the black poplar provides a readily acquired geochemical sample from an environment damaged by forest fire. The apparent lack of correlation between chemical elements in ashed plant tissue and mineralization is problematic. To assess this problem a thorough survey of the chemistry of the nutrient horizon(s) would be required. This would involve analysis of various soil horizons and determining the correlatibility between chemical elements in vegetation, soil and bedrock. A larger controlled survey using black poplar crowns is warranted to establish the full potential of this sample medium.

ACKNOWLEDGEMENTS

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TABLE 6

High concentrations of elements in the ash of plants growing over orebodies (Brooks, 1972).

ELEMENT	PLANT	ASH CONTENT(ppm)	REFERENCE
Cobalt	*Crotalaria cobalticola*	17,700	Duvigneaud (1959)
Copper	*Becium homblei*	2,500	Horizon (1959)
Chromium	*Pimelea suteri*	26,500	Lyon et al. (1968)
Lead	*Beilschmiedia tawa*	7,300	Nicholas and Brooks (1969)
Molybdenum	*Olearia rani*	1,600	Lyon and Brooks (1969)
Nickel	*Alyssum bertolonii*	100,000	Minguzzi and Vergnano (1948)
Selenium	*Astragalus pattersoni*	46,000	Cannon (1960)
Uranium	*Uncinia leptostachya*	25,000	Whitehead and Brooks (1969)
Vanadium	*Astragalus preussi*	1,680	Cannon (1960)
Zinc	*Viola calaminaria*	15,000	Linstow (1929)

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APPENDIX I

Part 1: Geochemical Analyses
Black Poplar (*Populus balsamifera L.*) Crowns
INAA
Ashed Sample

Part 2: Lower Limits of Detection

Part 1: Results for INAA of Ashed Black Poplar (*Populus balsamifera L.*) Crowns

		Au (ppb)	Ag (ppm)	As (ppm)	Ba (ppm)	Br (ppm)	Ca (%)	Co (ppm)	Cr (ppm)	Cs (ppm)
P-88-1	10N/3+10E	10	<2	5.1	390	8	21.9	20	6	3.2
P-88-2	10+5N/3+10E	8	<2	11.0	500	7	15.8	28	6	5.4
P-88-3	10N/3+25E	10	<2	12.0	500	12	19.4	27	4	5.5
P-88-4	9+95N/2+95E	6	<2	12.0	690	9	20.5	17	4	4.8
P-88-5	9+15N/3+12E	13	<2	4.2	440	8	21.1	13	6	1.8
P-88-6	9+15N/3E	8	<2	6.9	170	5	22.3	2	3	0.6
P-88-7	8+50N/2+88E	10	<2	7.0	290	8	19.5	7	4	1.6
P-88-8	8+50N/3E	<5	<2	3.5	110	6	22.9	3	3	0.6
P-88-9	8+50N/3+12E	10	<2	5.7	170	6	22.1	9	5	0.9
P-88-10	8+55N/3+25E	14	<2	3.6	160	4	22.1	3	6	<0.5
P-88-11	8+60N/3+37E	9	<2	6.6	290	7	19.3	7	4	0.8
P-88-12	8+65N/3+50E	10	<2	13.0	310	11	20.9	8	4	0.9
P-88-13	8+70N/3+60E	7	<2	4.6	190	6	24.6	7	4	0.5
P-88-14	8+75N/3+75E	7	<2	7.7	140	5	19.8	3	4	<0.5

		Cu* (ppm)	Fe (%)	Hf (ppm)	Hg (ppm)	Ir (ppb)	K (%)	Mo (ppm)	Na (ppm)	Ni (ppm)
P-88-1	10N/3+10E	253	0.10	<0.5	<1	<5	19.4	<2	219	<50
P-88-2	10+5N/3+10E	246	0.17	<0.5	<1	<5	18.0	<2	215	<50
P-88-3	10N/3+25E	187	0.09	<0.5	<1	<6	21.5	<2	192	<50
P-88-4	9+95N/2+95E	351	0.08	<0.5	<1	<5	20.7	<2	191	<50
P-88-5	9+15N/3+12E	220	0.12	<0.5	<1	<6	20.4	6	201	<50
P-88-6	9+15N/3E	237	0.05	<0.5	<1	<5	19.9	<2	165	<50
P-88-7	8+50N/2+88E	276	0.06	<0.5	<1	<6	24.5	<2	144	<50
P-88-8	8+50N/3E	263	0.06	<0.5	<1	<5	18.6	4	127	<50
P-88-9	8+50N/3+12E	264	0.07	<0.5	<1	<5	20.7	<2	167	<50
P-88-10	8+55N/3+25E	274	0.06	<0.5	<1	<5	20.0	<2	122	<50
P-88-11	8+60N/3+37E	362	0.09	<0.5	<1	<6	20.8	<2	125	<50
P-88-12	8+65N/3+50E	171	0.08	<0.5	<1	<6	21.3	3	201	<50
P-88-13	8+70N/3+60E	218	0.08	<0.5	<1	<5	17.9	<2	167	<50
P-88-14	8+75N/3+75E	282	0.06	<0.5	<1	<5	18.9	5	121	<50

		Rb (ppm)	Sb (ppm)	Sc (ppm)	Se (ppm)	Sr (ppm)	Ta (ppm)	Th (ppm)	U (ppm)	W (ppm)
P-88-1	10N/3+10E	570	0.2	0.2	<3	<190	<0.5	<0.2	<0.3	<1
P-88-2	10+5N/3+10E	590	0.2	0.1	<3	<170	<0.5	<0.1	<0.3	<1
P-88-3	10N/3+25E	770	0.3	0.1	<3	<210	<0.5	<0.2	<0.3	<1
P-88-4	9+95N/2+95E	450	0.3	<0.1	<3	<190	<0.5	<0.2	<0.3	<1
P-88-5	9+15N/3+12E	360	0.1	<0.1	<3	320	<0.5	<0.1	<0.3	<1
P-88-6	9+15N/3E	500	0.1	<0.1	<3	<170	<0.5	<0.1	<0.2	<1
P-88-7	8+50N/2+88E	580	<0.1	<0.1	<3	<200	<0.5	<0.2	<0.3	<1
P-88-8	8+50N/3E	390	<0.1	<0.1	<3	<180	<0.5	<0.1	<0.3	<1
P-88-9	8+50N/3+12E	670	<0.1	0.1	<3	<190	<0.5	<0.1	<0.3	<1
P-88-10	8+55N/3+25E	420	0.1	<0.1	<3	<200	<0.5	<0.1	<0.3	<1
P-88-11	8+60N/3+37E	850	0.1	<0.1	<3	<190	<0.5	<0.1	<0.3	<1
P-88-12	8+65N/3+50E	530	0.1	<0.1	<3	<180	<0.5	<0.1	0.4	<1
P-88-13	8+70N/3+60E	420	0.1	0.1	<3	<180	<0.5	<0.1	<0.2	<1

		Zn (ppm)	La (ppm)	Ce (ppm)	Nd (ppm)	Sm (ppm)	Eu (ppm)	Tb (ppm)	Yb (ppm)	Lu (ppm)
P-88-1	10N/3+10E	1800	1.5	<3	10	0.1	<0.08	<0.5	<0.07	<0.05
P-88-2	10+5N/3+10E	1800	1.6	4	10	0.2	<0.08	<0.5	<0.07	<0.05
P-88-3	10N/3+25E	1700	2.9	3	<5	0.2	<0.10	<0.5	<0.08	<0.05
P-88-4	9+95N/2+95E	1900	2.2	5	<5	0.1	<0.08	<0.5	<0.07	<0.05
P-88-5	9+15N/3+12E	1900	1.0	<3	<5	<0.1	<0.09	<0.5	<0.07	<0.05
P-88-6	9+15N/3E	1900	0.6	<3	<5	<0.1	<0.07	<0.5	<0.06	<0.05
P-88-7	8+50N/2+88E	2100	0.5	<3	<5	<0.1	<0.09	<0.5	<0.08	<0.05
P-88-8	8+50N/3E	2000	0.3	<3	<5	<0.1	<0.08	<0.5	<0.07	<0.05
P-88-9	8+50N/3+12E	1900	0.4	<3	8	<0.1	<0.08	<0.5	0.13	<0.05
P-88-10	8+55N/3+25E	3000	0.4	<3	<5	<0.1	<0.08	<0.5	<0.07	<0.05
P-88-11	8+60N/3+37E	2500	0.4	<3	<5	<0.1	<0.09	<0.5	<0.07	<0.05
P-88-12	8+65N/3+50E	2400	1.0	<3	<5	0.1	<0.07	<0.5	<0.08	<0.05
P-88-13	8+70N/3+60E	2000	0.7	<3	<5	0.1	<0.07	<0.5	<0.06	<0.05
P-88-14	8+75N/3+75E	1600	0.6	<3	<5	<0.1	<0.08	<0.5	<0.06	<0.05

* Cu determined on irradiated ash using a perchloric acid digestion and an atomic absorption spectrophotometric finish. Analysis by Barringer Laboratories (Alberta) Ltd.

Part 2: Lower Limits of Detection.

Element	Detection Limit	
Au	5	ppb
Br	1	ppm
Cs	0.5	ppm
Ir	2	ppb
Ni	50	ppm
Se	2	ppm
U	0.1	ppm
Ce	3	ppm
Tb	0.5	ppm
Ag	2	ppm
Ca	0.2	%
Fe	0.05	%
K	0.05	%
Rb	5	ppm
Sr	100	ppm
W	1	ppm
Nd	5	ppm
Yb	0.05	ppm
As	0.5	ppm
Co	1	ppm
Hf	0.5	ppm
Mo	2	ppm
Sb	0.1	ppm
Ta	0.5	ppm
Zn	20	ppm
Sm	0.1	ppm
Lu	0.05	ppm
Ba	10	ppm
Cr	1	ppm
Hg	1	ppm
Na	10	ppm
Sc	0.1	ppm
Th	0.1	ppm
La	0.1	ppm
Eu	0.01	ppm

Chemical elements analysed by Activation Laboratories Ltd. (Brantford) in the multi-element vegetation geochemical INAA package and detection limits.